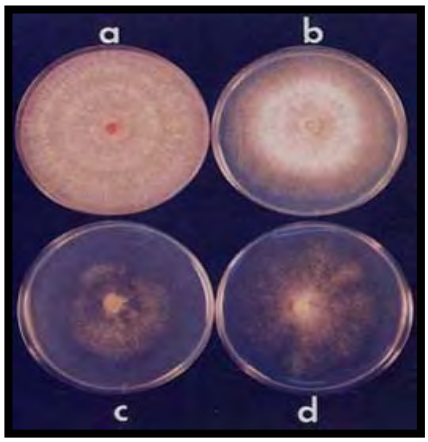
Floral & Nursery Plants Research Unit

In-Depth Laboratory Review Briefing Book

May 10-12, 2006



U.S. National Arboretum

FLORAL AND NURSERY PLANTS RESEARCH UNIT

In-Depth Program Review

May 10-12, 2006

U.S. National Arboretum
and
Beltsville Agricultural Research Center

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Agenda

Wednesday, May 10, 2006 – U.S. National Arboretum

10:00 - 12:00 **Review Team tour** - USNA laboratories, Herbarium, greenhouses, and nurseries

12:00 - 1:00 **Working lunch**

Public session, USNA Administration Building, Auditorium

1:00 - 1:10 **Welcome and Introductions**

1:10 - 2:20 **FNPRU Overview, Program Review**: *John Hammond, Research Leader*

2:20 – 2:35 **Question/Answer Session**

2:35 – 3:15 **Executive Session** – Review Team meets with Invited Guests

3:15 – 3:30 BREAK

Review Team Interviews with scientists, USNA Administration Building Conference Room

3:30 – 4:00 **Margaret R. Pooler**

4:00 – 4:30 **Richard T. Olsen**

4:30 – 5:00 **Sandra M. Reed**

5:00 – 5:30 **Alan T. Whittemore**

5:30 **Working Session**, transit to hotel

Thursday, May 11, 2006 - Beltsville Agricultural Research Center

8:00 – 10:15 **Review Team tour** - Beltsville laboratories, greenhouses, and South Farm

10:15 – 10:30 BREAK

Review Team Interviews with scientists, Building 010A Conference Room 200

10:30 – 11:00 **Kevin P. Conrad**

11:00 – 11:30 **Mark S. Roh**

11:30 – 12:00 **Donna C. Fare**

12:00 – 1:00 **Working Lunch**

1:00 – 1:30 **Scott E. Warnke**

1:30 – 2:00 **Dilip K. Lakshman**

2:00 – 2:30 **Kathryn K. Kamo**

2:30 – 3:00 **Robert J. Griesbach**

3:00 – 3:15 BREAK

3:15 – 3:45 **Qi Huang**

3:45 – 4:15 **Ramon L. Jordan**

4:15 – 4:45 **Hei-ti Hsu**

4:45 – 5:45 **John Hammond**

5:45 **Working Session**, transit to hotel

Friday, May 12, 2006 - Beltsville Agricultural Research Center, B-010A Conference Room 200

Review Team interviews with Support Staff

8:00 – 8:30 **Beltsville and USNA Support Staff**

8:30 – 9:00 **McMinnville Support Staff** (by telephone)

9:00 – 9:30 **Question/Answer Session** (BA Management Team, FNPRU Scientists)

9:30 – 12:00 **Working Session** – preparation of draft report

12:00 – 1:00 **Working Lunch – Executive Session**

1:00 – 2:00 Review Team meets with all FNPRU Scientists and Support Staff

Floral and Nursery Plants Research Unit In-Depth Review Team

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Invited Guests

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Western MD RC&D
Hagerstown, MD

Mr. Fred Ceballos
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Bonsall, CA

Dr. David Clement
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Ellicott City, MD

Mr. Frank Collier
Pleasant Cove Nursery
Rock Island, TN

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NC State University
Raleigh, NC

Ms. Barbara Deutsch
Casey Tree Foundation
Washington, DC

Mr. Robert Dolibois
ANLA
Washington, DC

Dr. Bob Faden
Smithsonian Institution
Washington, DC

Mr. John Farner
ANLA
Washington, DC

Mr. Douglas Fender
Turfgrass Producers Int.
Rolling Meadows, IL

Ms, Vanessa Finney
MNLA
Brooklandville, MD

Dr. Chris Frye
Maryland DNR
Annapolis, MD

Ms. Deborah Gangloff
American Forests
Washington, DC

Dr. Nick Gawel
TSU-NCRS
McMinnville, TN

Dr. Stanton Gill
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Paul Ecke Ranch
Encinitas, CA

Mr. Kerry Herndon
Kerry's Bromeliad Nursery
Homestead, FL

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Mr. Larry Hurley
Behnkes Nursery
Beltsville, MD

Mr. William Inglee
FONA
Washington, DC

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The Irrigation Association
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Ball FloraPlant
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Tennessee State University
Nashville, TN

Landscape Contractors Assoc.
Rockville, MD

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Mt. Cuba Center
Greenville, DE

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Burtonsville, MD

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Mr. Marvin Miller
Ball Horticultural Co.
West Chicago, IL

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Davidsonville, MD

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SAF
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Wilmington, DE

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Washington, DC

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Invited ARS Guests

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Plant Physiology and Cotton

Dr. Rick Bennett
National Program Leader
Plant Health

Dr. Evert Byington
National Program Leader
Rangeland, Pasture, and Forages

Prior Review Team Members (1998)

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Pennsylvania State University
State College, PA

Mr. Paul Ecke (deceased)
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Encinitas, CA

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Introduction to the Floral and Nursery Plants Research Unit

The history of the Floral and Nursery Plants Research Unit dates back to the late 1930's when the predecessor of the "Florist and Nursery Crops Laboratory" was established in Beltsville to pursue research on the development of new and improved floral and nursery products. Over the years the laboratory focused on genetic improvement and disease control of major cut flowers and flowering pot plants, This research included a wide variety of crops including roses, carnations, chrysanthemums, poinsettias, hydrangeas, lilies, gladiolus, bulbous iris, azaleas, and many other crops. In more recent years the laboratory has developed several new programs involving both basic and applied research focused on floral crop improvement. These programs added capabilities in tissue culture, new crop development, biotechnology, and entomology. New pathology programs included genetic engineering, virus-induced plant resistance, biological control, development of new tools for pathogen detection, and development of natural products for pest and disease control. New plants continued to be released, including types that have become industry standards; these include the current number one bedding plant, New Guinea Impatiens.

The former "Research Unit" at the National Arboretum had been nationally and internationally recognized for contributions in plant breeding and taxonomy. The program emphasized tree and shrub breeding, and taxonomy of cultivated plants. The introduction of new cultivars of *Lagerstroemia, Viburnum, Pyracantha, Hibiscus, Pyrus, Ilex, Malus* and many other introductions have been widely distributed and popularized by the nursery industry. Tree breeding has resulted in introductions of pest and disease resistant *Ulmus* and *Acer* as well as new forms of *Magnolia*. Many of these new trees and shrubs have been given awards for their horticultural and ornamental superiority. The herbarium at the National Arboretum contains more than 600,000 specimens and represents one of the largest and most outstanding collections of ornamental and cultivated plants in the United States.

In the summer of 1993, the "Florist and Nursery Crops Laboratory" (9 SYs; Plant Sciences Institute; Beltsville, MD) was combined with the "Research Unit" and the "Germplasm Unit" at the U.S. National Arboretum (5 SYs) to form what is now called the "Floral and Nursery Plants Research Unit". The purpose of this union was to integrate a wider variety of science disciplines and new biological technologies into both the woody plant shrub and tree program and the floral crop research. In late 1996, the 'small trees and shrub breeding program' at the McMinnville, TN worksite (2 SYs) was also added to the Unit. This approach brought a wide range of scientific talent to focus on the highest priority problems with the most efficient use of resources.

In 2000, additional base funding resulted in addition of a bacteriologist to the 'Pathology' research team, and in 2001 a further addition established the 'Turf breeding' position. The activities and expertise of the former National Arboretum "Research Unit" with their woody plant expertise have been thoroughly integrated with the herbaceous plant expertise of the former "Florist and Nursery Crops Laboratory" to create a highly interactive group. The Floral and Nursery Plants Research Unit has unique programs that historically have contributed and are expected to continue to contribute significantly to the environmental horticulture industry.

Floral and Nursery Plant Research Unit – Mission Statement

The Floral and Nursery Plants Research Unit conducts a broad based program of basic and developmental research that contributes to the introduction of new cultivars and the implementation of new technologies for the florist and nursery industries.

Emphasis is placed on developing new and superior floral and woody nursery plants.

In addition, the Unit has the responsibility to collect, propagate, maintain, distribute, evaluate and preserve representative levels of inherent genetic diversity of woody landscape plants as part of the National Plant Germplasm System.

[The FNPRU Website at http://www.usna.usda.gov/Research/index.html was last updated April 17, 2006]

Genetics, Genetic Resource Evaluation, and Genetic Improvement of Landscape Trees and Shrubs (1230-21000-041-00D)

Objectives:
1. Characterize, evaluate, breed, select, and release woody landscape plant germplasm.
2. Establish molecular markers in specific genera, primarily *Prunus*, *Cercis*, and *Lagerstroemia* to aid in characterization, identification, selection and/or evaluation of plant material.
3. Use tissue culture to recover progeny from wide hybridizations and to perform chromosome manipulations, and use biotechnology to introduce new genes into cultivated germplasm of particular taxa.
4. Coordinate cooperative programs with the nursery industry to evaluate new selections and propagate new releases, to ensure transfer of this research to the end users.

Investigators:
Margaret R. Pooler, Research Geneticist, 1.0

Financial Resources (net to location):
$594,354

Expected Outcomes:
New cultivars of landscape trees and shrubs will create marketing opportunities for the nursery and landscape industries, and increase choice for consumers. New cultivars that have enhanced tolerances to disease, pests, and environmental stresses will require less input of pesticides and natural resources, and therefore contribute to more sustainable management practices in both nursery settings and in the urban and suburban landscapes. The use of these plants can contribute to the overall quality of life by creating aesthetic appeal, preventing erosion, screening views, and reducing noise and air pollution. Technology and germplasm created by this research can be used by researchers in government, university, and private sectors. Outputs include new cultivars of landscape trees and shrubs that have enhanced tolerances to disease, pest, and environmental stresses and are of superior ornamental value, germplasm that has been evaluated or enhanced for various traits, and technology and results on molecular markers, gene manipulation, and wide hybridization.

Extramural support:
58-3K95-2-903 (CRADA with McCorkle Nurseries, Dearing, GA)
Title: Evaluation and hybridizations of the box huckleberry for use as a landscape plant
Investigators: Margaret Pooler, Rob Greisbach Funded amount: $25,000
Start date: 9/2/01 End date: 9/1/03

58-1230-5-410 (Trust agreement with J. Frank Schmidt Family Charitable Foundation)
Title: Assessing the genetics of flowering cherry taxa using SSR markers
Investigators: Margaret Pooler, Hongmei Ma Funded amount: $6,000
Start date: 10/1/04 End date: 12/31/06

58-1230-4-400 (Trust agreement with J. Frank Schmidt Family Charitable Foundation)
Title: Assessing the genetic diversity and authenticity of cultivars and clones of American elm and related taxa
Investigators: Margaret Pooler, Denny Townsend Funded amount: $5,000
Start date: 1/1/04 End date: 12/31/04

58-1230-1-004 (Trust agreement with J. Frank Schmidt Family Charitable Foundation)
Title: Screening woody ornamental landscape plants for ability to regenerate in tissue culture

Investigator: Margaret Pooler Funded amount: $2,500
Start date: 9/30/00 End date: 12/31/02

Temporary additional funding from NPS in conjunction with pass-through for Specific Cooperative Agreements (SCAs)
Title: Developing non-invasive nursery crops
Investigator: Margaret Pooler (in-house) Funded amount: $50,000 (03), $75,000 (04), $74.019 (05)
Start date: 8/03 End date: (9/30/05)

1230-21000-041-01S (SCA with North Carolina State University, NPS directed)
Title: Developing non-invasive nursery crops
Investigators: Tom Ranney (Margaret Pooler) Funded amount: $75,000 (03), $115,000 (04), $113,496 (05)
Start date: 9/1/03 End date: 8/31/08

1230-21000-041-02S (SCA with Oregon State University, NPS directed)
Title: Developing non-invasive nursery crops
Investigators: Steve Strauss (Margaret Pooler) Funded amount: $75,000 (03), $75,000 (04), $74,019 (05)
Start date: 9/1/03 End date: 8/31/08

OSQR Review:
Approved 11/21/2003. Termination date: 10/31/2008

Genetic Improvement Of Landscape Trees For Superior Pest Resistance (1230-21000-043-00D)

Objectives:

The primary goals for this project are to genetically characterize and evaluate the horticultural merit and pest resistance contained in *Tsuga*, *Ulmus*, *Celtis*, and *Nyssa* genetic resources; from the preceding materials incorporate into breeding populations new or improved sources for pest resistance; and from the preceding breeding stocks develop and transfer superior landscape tree cultivars to end users. Objectives 1 and 2 will be accorded highest priority.

1. Evaluate hemlock (*Tsuga*) hybrids and species for resistance to the hemlock woolly adelgid and determine the relative levels of resistance and susceptibility.
2. In a replicated trial, evaluate the relative Dutch elm disease tolerance of 20 selected clones of American elm (*Ulmus americana*); and continue breeding and selecting non-American elms for superiority in disease and insect tolerance; form; adaptability; and sterility.
3. In preliminary work, establish breeding populations of hackberry (*Celtis*) and tupelo (*Nyssa*) for future evaluation and genetic improvement of disease- and insect-resistance and of desirable horticultural attributes.
4. Carry out technology transfer by propagating and distributing for evaluation germplasm of alder *(Alnus*), elm (*Ulmus),* hornbeam (*Carpinus*), maple (*Acer*), and zelkova (*Zelkova)* to end-users (nurserymen).

Investigators:

Richard T. Olsen, Research Geneticist, 1.0 (effective 4/06; Alden Townsend retired 1/05)

Financial Resources (net to location):

$495,011

Expected Outcomes:

Useful new knowledge resulting from this research will be communicated to the scientific community, industry groups, and the general public. The release of superior, pest-resistant landscape trees will benefit the American public by increasing tree survival rates, decreasing tree maintenance costs, and decreasing the use of certain toxic or hazardous pesticides. Increased genetic diversity and choices for ornamental and street tree use will reduce the risk of pest- and disease-susceptibility inherent in monocultures. Other outs will include: new scientific knowledge; the release of genetically superior landscape tree cultivars; and development of new techniques and technologies for tree breeders.

Extramural support:

308-1230-459 (Reimbursable agreement with the U.S. Forest Service)
Title: National Arboretum Out-Planting Demonstration Project
Investigators: John Hammond, Susan Bentz Funded Amount: $5,000
Start Date: 5/1/03 End Date: 9/30/04

58-1230-4-0405 (1230-21000-043-01R) (Reimbursable agreement with Western Maryland RC&D Council, Hagerstown, MD)
Title: Utility-Adapted Tree Research, Production, and Out-Planting Project
Investigators: John Hammond, Susan Bentz. Funded Amount: $34,881
Start Date: 5/15/2004 End Date: 7/30/2007

58-1230-4-0405 (1230-21000-043-41R) (Reimbursable agreement with Western Maryland RC&D Council, Hagerstown, MD)

Title: Utility-Adapted Tree Research, Production, and Out-Planting Project, Phase II
Investigators: John Hammond, Susan Bentz. Funded Amount: $50,000
Start Date: 7/1/2005 End Date: 7/30/2007

50-1230-5-0413 (1230-21000-043-03R) (Reimbursable agreement with U.S. Forest Service)
Title: Developing a Vegetatively Propagated Hemlock Evaluation Network
Investigators: John Hammond, Rob Griesbach, Susan Bentz Funded Amount: $52,000
Start Date: 7/1/2005 End Date: 9/30/2007

OSQR Review:
Approved 11/19/2003. Termination date: 10/31/2008

Genetics, Genetic Improvement, and Improved Production Efficiency of Nursery Crops (1230-21000-042-00D)

Objectives

1. Genetically characterize and evaluate the ornamental merit, disease and insect resistance, and stress tolerance of selected nursery crop species and incorporate these traits into new or improved cultivars or breeding lines.
2. Identify plant physiological constraints with nursery crops, develop improved production systems, and evaluate germplasm of ornamental trees and shrubs for landscape value.

Investigators

Sandra M. Reed, Research Geneticist, 1.0
Donna C. Fare, Research Horticulturist, 1.0

Financial Resources (net to location)

$652,209

Expected Outcomes

1. Cultivars and breeding lines of ornamental trees and shrubs
2. Environmentally sound, cost-efficient production systems for the nursery and landscape industry
3. Information on: genetics and breeding systems in selected nursery crop species; sources of germplasm for plant improvement efforts; and, plant physiological response to nursery production stress

Extramural Support

1230-05-00 022839 (Grant from J. Frank Schmidt Family Charitable Foundation)
Title: Management of Buprestid Borer with Newly Planted Tree Liners.
Investigator: Donna C. Fare and Jason Oliver Funded amount: $3,500
Start Date: 09/00 End date: 12/01

1230-05-00 021261 (Grant from Tennessee Nursery and Landscape Association)
Title: Spring Weeds Controlled by Fall Herbicide Application in Field and PNP Nurseries
Investigator: Donna C. Fare and Mark Halcomb Funded amount: $1,000
Start Date: 01/02 End date: 12/02

1230-05-00 025755 (Tennessee State University via Horticultural Research Institute)
Title: Species of Flatheaded Borer Impacting the Ornamental Industry and a Method to Survey for Borer Activity within Field Nurseries
Investigator: Donna C. Fare and Jason Oliver Funded amount: $16,000 ($3,000 to FNPRU)
Start Date: 01/03 End date: 12/04

1230-05-00 024518 (Grant from Horticultural Research Institute)
Title: Liners Affected by Bare Root Production Practices
Investigator: Donna C. Fare and James Altland Funded amount: $ 25,000 ($10,000 to FNPRU)
Start Date: 03/04 End date: 12/03

1230-05-00 0027035 (Grant from Horticulture Research Institute)
Title: Developing improved woody ornamentals through interspecific hybridization
Investigator: Sandra Reed Funded amount: $8000
Start date: 01/05 End date: 12/06

Fund transfer from Poplarville, Miss. to facilitate inter-location collaborative research. (Provides salary and support for post-doctoral research associate.)
Investigator: Sandra Reed Funded amount: $255,000
Start date: 10/03 End date: 09/06

1230-21000-032-2S (Specific Cooperative Agreement #58-1230-8-101, NPS-directed)
Title: Nursery and Landscape Robotics and Automation
Investigator: Hagan Schempf, Carnegie Mellon University Funded: $ 901,516.00 ($270,000 to FNPRU)
Start date: 09/98 End date: 08/03\

Temporary additional funding from NPS in conjunction with pass-through for Specific Cooperative Agreements (SCAs)
Title: Environmental Resource Management Systems for Nurseries, Greenhouses, and Landscapes
Investigator: Donna Fare (in-house) Funded amount: $15,830 (03), $15,830 (04), $15,411 (05)
Start date: 8/03 End date: (9/30/05)

1230-21000-042-02S (Specific Cooperative Agreement #58-1230-2-0044, NPS-directed)
Title: Environmental Resource Management Systems for Nurseries, Greenhouses, and Landscapes
Investigator: Christopher Catanzaro, Tennessee State University Funded: $45,835
Start date: 04/02 End date:07/07

1230-21000-042-01S (SCA with Tennessee State University, voluntary)
Title: Cooperative research and operations between Tennessee State University and ARS
Investigator: Sandra Reed Funded amount: $175,000 to TSU
Start date: 07/02 End date: 07/07

OSQR Review
Date of review: September 24, 2003
CRIS termination date: October 31, 2008

Taxonomy and Genetic Diversity Assessment of Landscape Trees and Shrubs (1230-21000-039-00D)

Objectives:

1. Investigate classification, systematic relationships, and genetic structure within genera and families with current or potential importance for landscape and nursery use. Work will concentrate on the following projects:
   A. The hackberries and sugarberries: *Celtis* subgenus *Celtis*. Investigations will focus on the classification and interrelationships of the species native to North America, the systematic relationships of the North American and Eurasian species, and the role of interspecific hybridization in nature and in breeding programs.
   B. The oaks: the genus *Quercus*. Investigations will focus on the genetics of particular species groups native to North America, investigating the distribution of genetic variation within and among species, and methods for reconstructing phylogeny in the presence of occasional interspecific hybridization.
   C. Projects of limited scope relating to other families and genera will be undertaken as need for them is expressed by other scientists and horticulturists.
2. Maintain and enhance the herbarium collection of the National Arboretum.
3. Investigate the identity and basic biological characteristics of selected invasive woody plants in the U. S.
4. Nomenclature. Ensure that botanical and cultivar names in use for cultivated plants, and for wild plants that may be of relevance for breeding work, are described in accordance with the technical standards of the field and that erroneous or ambiguous usages are corrected.

Investigators:

Alan T. Whittemore, Research Taxonomist, 1.0.

Financial Resources: (net to location)

$408,735

Expected Outcomes:

This research will result in improved understanding of plant relationships and the distribution of genetic variation within and among species, more accurate classifications that reflect this understanding, and genetic markers (both molecular and morphological) that can be used to identify and characterize germplasm, assess parentage of crosses, and assist in selecting for desirable characteristics. This work will allow plant breeding and plant germplasm collecting and maintenance programs to work more efficiently and more accurately. The herbarium provides rigorous documentation of many important research and breeding collections, and of representative specimens of American nursery and landscape plants, and provides a resource for accurate plant identifications for scientists, plant breeders, and nurserymen.

Extramural Support:

None

Genetic Enhancement of Turfgrass Germplasm For Reduced Input Sustainability (1230-21000-045-00D)

Objectives:

The objective of this research is to use genetic and biotechnology approaches to identify and develop turfgrass germplasm with improved biotic and abiotic stress resistance. The two broad goals for the next 4 years are: 1) to develop molecular marker systems suitable for genetic map development and rapid diversity assessment in important turfgrass species. 2) develop tissue culture procedures for the production of haploids, doubled haploids, and embryo rescue of wide species crosses. The specific objectives over the next five years are:

1. Evaluate genetic diversity of Tall Fescue (*Festuca arundinacea* L.) and identify potential sources of disease resistance to brown patch caused by (*Rhizoctonia solani*).
2. Begin development of recombinant inbred line mapping populations in ryegrass (*Lolium sp*.)
3. Examine fescue-ryegrass hybridization using embryo rescue techniques and generate molecular markers suitable for identifying interspecies hybrids with improved biotic and abiotic stress resistance
4. Initiate studies on the vegetative to reproductive phase change in creeping bentgrass (*Agrostis stolonifera* L.) to identify genes with potential for flowering control.
   Sub-objective - Identify creeping bentgrass clones with high rates of self-fertility for use in the development of recombinant inbred populations.

Investigator:

Scott E. Warnke, Research Geneticist, 1.0

Financial Resources: (net to location)

$448,286

Expected Outcomes:

New germplasm of important cool season turfgrass species such as Tall Fescue, Fine Fescue, Creeping Bentgrass and Kentucky Bluegrass (*Poa pratensis*), with enhanced disease and stress resistance. The development of improved selection methods, utilizing molecular markers to enhance selection efficiency for traits such as disease resistance and stress tolerance, which will allow turf breeders to produce improved varieties more efficiently. The identification of genes that can be used to improve turfgrass biotic and abiotic stress tolerance. The identification of genetic mechanisms, which improve flowering under seed production conditions while suppressing flowering under turf conditions would significantly improve turf quality and stress resistance. In order to control flowering it will be necessary to place the genes that control flowering under the control of inducible promoters that would suppress flowering under turf conditions. Identified genes may also be of benefit in other important grasses used for food and feed.

Genetic Improvement of Floral Crops for Pest, Disease, and Stress Tolerance and Ornamental Qualities (1230-21000-040-00D)

Objectives:
The primary goal for this project is floral plant improvement, focusing on anthocyanin pigmentation and virus resistance. The specific goals are to elucidate the genetic control for anthocyanin pathways and production, using the Solanaceous crops Petunia and Capsicum as model plants; develop genetically improved Petunia and Capsicum germplasm with novel ornamental traits and/or improved pest, disease and stress tolerance; develop transgenic floral crops with induced resistance to viral diseases; and determine how viruses may regulate anthocyanin biosynthesis in the phenomenon known as "color-break."

1. Determine the expression and control of structural and regulatory genes for anthocyanin coloration of leaves, flowers, and fruit, including viral effects on flower-break.
2. Develop Petunia and Capsicum germplasm with novel characteristics and/or pest, disease and stress tolerance.
3. Initiate development of transgenic floral crops exhibiting induced resistance to selected major viral diseases.

Investigators:
Robert J. Griesbach, Research Geneticist, 1.0; Ramon Jordan, Research Plant Pathologist, 0.5; John Hammond, Research Plant Pathologist, 0.45.

Financial Resources: (net to location)
$684,435

Expected Outcomes:
This research will result in the release of new germplasm which can be used to develop new cultivars. The floral industry relies upon the USDA as one of their major sources of enhanced germplasm. The industry is composed of many small growers which cannot internally support new crop development, germplasm enhancement, disease / stress tolerance breeding, or use biochemical procedures in selection. In addition, there are no sources of virus resistance in the available germplasm of many ornamental species, yet virus infection is a major constraint on both productivity and quality. Whereas virus-free plants of some species can be generated by growing them from seed, this option is not available for many hybrid, self-incompatible, or vegetatively propagated cultivars. Virus-free plants of other species may be obtained through meristem-tip culture or thermotherapy. However, virus-free plants without resistance are readily re-infected. Transgenic plants expressing viral and anti-viral genes will be created to confer virus resistance and to understand the mechanisms of resistance. An understanding of the mechanisms of viral flower break should increase our ability to manipulate flower color in ornamentals.

New enhanced germplasm will be developed and released. In addition, to germplasm, this research will result in new technology and information on the inheritance of pigmentation, evolution, and virus resistance. New genes and transformation procedures will be developed that can be widely used without significant licensing restrictions.

Extramural Support:
1275-2100-110-00D (PanAmerican Seed CRADA 58-3K95-9-769)
Title: Development of Enhanced Capsicum Germplasm for Ornamental/Culinary Applications
Investigators: J.R. Stommel and R.J. Griesbach Funded amount: $12,000.00
Sart date: 8/99 End date: 8/03

1230-2100-040-08T (McCorkle Nurseries and Kerry's Bromeliad Nursery CRADA 58-3K95-5-1074)

Title: Genetics of Anthocyanin Regulatory Genes
Investigators: R.J. Griesbach and J.R Stommel Funded amount: $60,000.00
Start date: 10/04 End date: 10/07

Genetic Engineering Of Floral Bulb Crops For Virus And Nematode Resistance (1230-21000-037-00D)

Objectives

1. Evaluate methods of gene silencing, such as RNAi, to suppress viral pathogen propagation in floral monocots, and develop gene silencing-based viral resistance in *Gladiolus* and lilies for evaluation.
2. Utilize transformation to improve resistance of bulb crops to fungal diseases and plant parasitic nematodes. (a) Develop transformation technology for Easter lily; (b) test candidate genes to confer resistance to *Fusarium* in *Gladiolus*; and (c) determine whether dsRNA expressed in plants can target RNAi to control plant parasitic nematodes.

Investigators

Kathy Kamo, Plant Physiologist, 1.0; John Hammond, Research Leader, 0.05

Financial Resources (net to location)

$392,260

Expected Outcomes

Information about gene silencing in floral monocots will be acquired.
Transgenic *Gladiolus* and lilies with traits of horticultural importance will be developed and evaluated.
Promoters and gene constructs useful in virus and nematode resistance will be developed.

Extramural Support

1230-21000-026-00D (Trust fund with Sanford Scientific, Inc.)
Title: Genetic engineering of roses
Investigator: K. Kamo Funded amount: $15,000
Start date: 1/00 End date: 12/01

1230-21000-037-01T (Trust fund with the Korea Rural Development Administration)
Title: Lily transformation
Investigator: K. Kamo Funded amount: $66,000
Start date: 1/00 End date: 12/03

OSQR Review

Date of review: 1/30/06 End date: 1/30/11

Genetic Resources, Evaluation, and Information Management of Woody Landscape Plant Germplasm (1230-22000-049-00D)

Objectives

1. Collect and conserve genetic resources
   - Sub-objective 1 - Collect and conserve genetic resources and associated information for a broad spectrum of woody landscape plants
   - Sub-objective 2 - Lead USDA/ARS's component of the North American Plant Collection Consortium (NAPCC) and North America-China Plant Exploration Consortium (NACPEC)
   - Sub-objective 3 - Move germplasm from the prior site at Glenn Dale, MD to the new site on the South Farm of Beltsville Agricultural Research Center-West (BARC-W), MD and the U.S. National Arboretum, Washington, D.C.
2. Evaluate the preceding genetic resources for horticultural merit, and characterize them genetically
3. Transfer technology in the form of the preceding genetic resources and associated information to researchers and breeders world wide

Investigators

Kevin Conrad, Horticulturist, 1.0; Mark S. Roh, Research Horticulturist, 1.0.

Financial Resources (net to location)

$640,577

Expected Outcomes

Objective 1. Collect and conserve genetic resources

Germplasm will be collected, established, and exchanged with other institutions; accessions will be documented in the USNA Herbarium. APGA/ NAPCC collections evaluators will be trained and an article written for APGA. Germplasm will be received for distribution among NACPEC institutes, and information provided for materials from previous collection trips. Additional germplasm will be acquired through NACPEC trips, and germplasm will be distributed in response to requests. We will complete the move from Glenn Dale to the new South Farm site.

Objective 2. Evaluate the preceding genetic resources for horticultural merit, and characterize them genetically

Complete work on seed germination, vegetative propagation and overwinter loss of *Styrax*.

Evaluate *Halesia* and *Deutzia* propagation results, conduct field studies, and release selected lines.

Complete temperature and growth response studies, and carbohydrate anlyses, on *Pinus* and *Abies* seedlings.

Complete molecular marker analysis of *Ilex* × *wandoensis* by RAPD and ISSR, and establish selected germplasm.

Identify molecular markers for cold hardiness of *Camellia*, establish seedlings and test for hardiness.

Complete microsatellite analysis for *Halesia*, and hybridity analyses in *Deutzia* and *Corylopsis*.

Objective 3: Transfer technology in the form of the preceding genetic resources and associated information to researchers and breeders world wide

Germplasm will be distributed, and the GRIN database and WLPGR web pages updated; research results publish will be published in appropriate scientific and trade journals, and new hybrid germplasm released to cooperators to evaluate for potential cultivar release.

Extramural Support

1230-05-00 021803 (Trust Fund Cooperative Agreement, Collaboration with the Holly Society of America)
Title: Characterization of *Ilex* x *wandoensis* C. F. Miller ex. T. R. Dudley in ed using molecular markers.
Investigator: Mark S. Roh Funded amount: $ 3,500

Start date: 10/02 End date: 06/06

1230-21000-029-03T (Trust Fund Cooperative Agreement, collaboration with Rural Development Administration, Korea)
Title: Development and usage of woody plants (*Camellia, Styrax, Corylopsis*) for landscape use and potted plant production.
Investigator: Mark S. Roh Funded amount: $57,000
Start date: 06/03 End date: 06/06

OSQR Review
Start Date: 6/11/2004 End Date: 10/31/2008

Biologically Based Management Strategies For Control Of Soil-Borne Pathogens Of Ornamental Crops As An Alternative To Methyl Bromide Pre-Plant Soil Fumigation (1230-22000-019-00D)

Objectives:

Methyl bromide has been a major component of management strategies for controlling important diseases of many crops including ornamentals grown in the United States. The phase-out of methyl bromide creates a critical need in the agricultural community for methyl bromide replacements. My research is directed at investigating the development, characterization and use of hypovirulent isolates, exploration and development of organic amendments and biorationals, and the use of microbial antagonists in combination with reduced risk pesticides in the management of *R. solani* and other soil-borne fungal pathogens. Research will also be directed at understanding fundamental aspects of these technologies. In this regard, proposed work is directed at determining and characterizing factors (double-stranded RNAs and metabolites of the shikimate and quinate pathways) affecting hypovirulence and improving biocontrol consistency and efficacy through the combination of organic amendments including composts, and reduced risk fungicide(s). Research on compost will focus on development of compost from conifer waste (pine needles, cones, bark and sawdust), usability as an amendment in the potting medium, compatibility with biocontrol agents, and its effect on soil-borne disease suppression. Finally, various biocontrol organisms will be evaluated along with chemicals, composts and reduced-risk fungicides to develop an efficient soil-borne disease-control strategy for selected ornamental crops. Specific objectives are:

1) Investigate, develop characterize and use hypovirulent isolates for the control of soil-borne pathogens causing damping-off and stem rot diseases in ornamental crops, with emphasis on *R. solani*.
2) Explore and develop organic amendments and biorationals for the management of soil-borne pathogens inducing damping-off and stem rot diseases in ornamentals with emphasis on *R. solani*.
3) Investigate the effectiveness of microbial antagonists in combination with reduced risk pesticides in the management of *R. solani* and other soil-borne pathogens.

Investigator:

Dilip K. Lakshman

Financial Resources: (net to location)

$230,429

Expected Outcomes:

This research would result in the development of hypovirulent isolates of *Rhizoctonia solani* with potential for biocontrol of the ubiquitous soilborne fungal pathogen in ornamentals and other crops. This study would also lead to a greater understanding of molecular basis of pathogenicity and virulence of the pathogen. Experiments on botanical extracts and organic amendments with potential antimicrobial and/or disease suppressive activities will lead to safer formulations for biocontrol of soilborne pathogens. Combining biocontrol methods with reduced risk pesticides should lead to better and acceptable disease management practices.

Development of Detection and Protection Technologies for Viruses and Bacteria of Major Significance to Ornamental and Nursery Crops (1230-22000-012-00D)

Objectives

1. Investigate and characterize viruses of major significance to ornamental and nursery crops (annuals, perennials, woody ornamentals, bedding plants, and bulb crops). These viruses include, but are not limited to: potyviruses (including plum pox virus), tospoviruses, fabaviruses, pelarspoviruses, closteroviruses, cucumber mosaic virus, arabis mosaic virus, dahlia mosaic virus, and "new" currently uncharacterized or emerging viruses affecting key ornamental crops. Develop serological reagents, molecular probes and diagnostic technologies for the detection and management of diseases caused by the viruses listed above.
2. Determine the genome organization of selected important ornamental viruses and develop full-length infectious clones to determine the genes or gene products involved in pathogenicity and their mode of action.
3. Develop and utilize anti-viral and anti-bacterial genes in the production of transgenic floral crops exhibiting induced resistance to selected major viral and bacterial diseases. Identify and develop alternative plant expression promoters.
4. Conduct research on the host range, epidemiology and non-pesticidal control of bacterial wilt disease of geranium caused by *Ralstonia solanacearum* race 3.
5. Develop knowledge and tools for the detection and control of bacterial leaf scorch disease of woody ornamental crops caused by *Xylella fastidiosa*. Characterize the genome of ornamental strains of *X. fastidiosa*, their relationships with hosts and vectors, and develop methods for disease control.

Investigators

Ramon Jordan (Lead SY), Research Plant Pathologist (0.5); John Hammond, Research Plant Pathologist (0.5); Hei-Ti Hsu, Microbiologist (1.0); Qi Huang, Research Plant Pathologist (1.0).

Financial Resources (net to location)

$1,094,083

Expected Outcomes

The proposed research addresses the development of more effective means for the detection and identification of plant virus and bacterial diseases affecting ornamentals and to utilize those methods to allow selection of pathogen-free or pathogen-indexed plants. Improved knowledge of viral and bacterial genome structures and functions, the mechanisms of viral and bacterial pathogenicity and the diseases they cause in ornamental crops will result in the development of improved detection reagents and technologies and effective integrated control strategies; including early detection of the pathogens, control of insect and nematode vectors, identification of alternate hosts, sanitation protocols and development of resistant cultivars. The development of anti-pathogen reagents and genes should lead to the development of better control measures and facilitate the development and commercialization of genetically-engineered ornamental crops for viral and bacterial disease resistance in plants. This will ultimately lead to increases in both productivity and quality of ornamental plants for industry and the consumer.

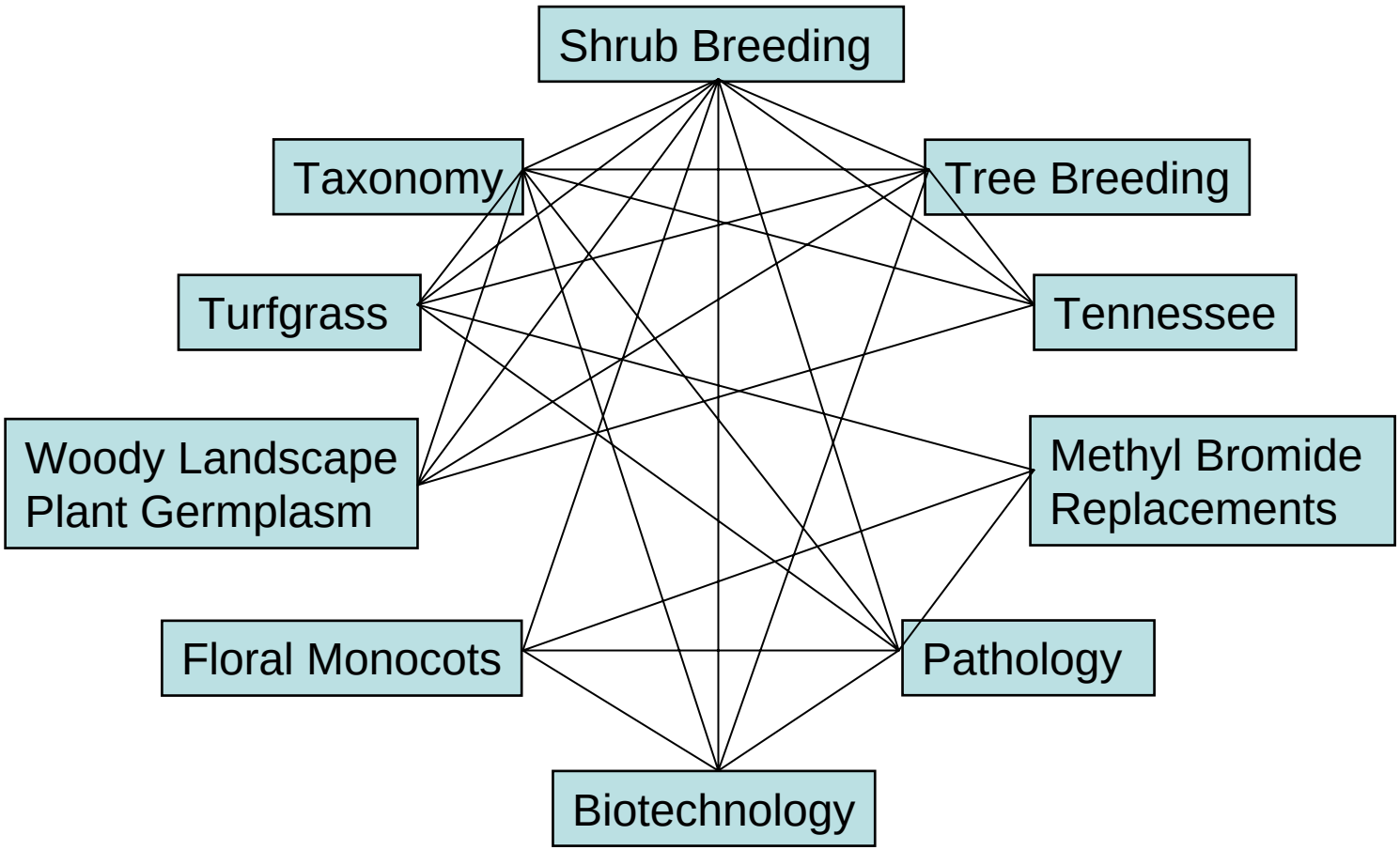
Extramural Support

1230-22000-012-10T [Trust Fund Agreement, collaboration with Agdia, Inc]
Title: Development of improved pathogen detection methodologies and reagents based on PCR and hybridization technologies
Investigators: R. Jordan Funded amount: $6,000 net total
Start date: Oct, 2005 End date: Sept, 2007

1230-22000-012-11T [Cooperative Research and Development Agreement, collaboration with Agdia, Inc]
Title: Development of new, superior plant virus detection methodologies and reagents
Investigators: R. Jordan (PI), J. Hammond, H. Hsu Funded amount: $24,000 net total
Start date: Oct, 2005 End date: Sept, 2008

Temporary funds, NPS-directed; Source: Floral and Nursery Research Initiative
Title: Characterization, distribution and detection of emerging and unknown viruses infecting ornamental plants
Investigators: J. Hammond, H. Hsu, R. Jordan
Funded amount: $30,150 (02), $30,150 (03), $30,150 (04), $29,757 (05)
Start date: Oct, 2002 End date: Oct, 2005

OSQR Review
OSQR Approved: 11/02/2002 CRIS Start date: 01/10/2003 CRIS Termination date: 01/09/08
CRIS NP-303 Review Cycle: 05/01/2006 – 02/17/2007



FNPRU CRIS Project Interactions

Genetics, Genetic Resource Evaluation, and Genetic Improvement of Landscape Trees and Shrubs (1230-21000-041-00D)

Accomplishment: ***Seven superior cultivars of landscape plants have been released to the nursery industry in the last six years, including 'Arapaho' and 'Cheyenne' crapemyrtles; 'First Lady' flowering cherry; 'Don Egolf' redbud; and 'Betsy Ross', 'Old Glory', and 'Declaration' lilacs***. **Role**: Former (Egolf) and current (Pooler) scientists in the Shrub Breeding CRIS bred, selected, and evaluated these selections, as well as initiated commercial propagation efforts, named, wrote release notices, released, and promoted these cultivars. **Impact**: The green industry (including plants and hard goods) ranks third in the nation, behind corn and soybeans, in gross agricultural cash receipts with an estimated $49 billion economic impact. The introduction of superior woody landscape cultivars to the nursery industry is a vital role that the shrub breeding program plays in contributing to this booming industry. These cultivars offer nursery growers, landscape contractors, and the gardening public new and superior choices in plant material.

Accomplishment: ***A molecular marker system was established using automated sequencing equipment with fluorescently labeled primers as an efficient and reliable system to fingerprint woody plant germplasm to aid in genetic diversity estimates and to identify hybrid progeny***. **Role**: This project was initiated in the Shrub Breeding CRIS, with cooperation from and further development by scientists and support personnel in the Trees, Taxonomy, Germplasm, Biotech, and Turf CRIS. **Impact**: Molecular markers have been used successfully to assess diversity or establish genetic relationships in hemlock, crapemyrtle, hamelia, elm, box huckleberry, flowering cherry, hackberry, and turf species. The use of AFLP and SSR molecular markers to characterize germplasm has become routine in our lab.

Accomplishment: ***A reliable regeneration system has been developed for two important landscape plants*** - ornamental flowering cherry using embryogenic callus or direct organogenesis from leaf pieces, and redbud species using direct organogenesis from leaf pieces. **Role**: This work was conducted by the visiting scientist (Cheong) and the lead scientist (Pooler) in the Shrub Breeding CRIS. **Impact**: Regeneration of plants in vitro is the first step in gene transfer using biotechnology. This research could lead to the development of cultivars with novel genes for disease or pest resistance, cold hardiness, flower traits, fragrance, plant architecture, or reproduction.

Genetic Improvement of Landscape Trees for Superior Pest Resistance (1230-21000-043-00D)

Accomplishment: ***Release of 'Jefferson' elm and evaluation of Dutch elm disease tolerance in American elm selections and seedlings.*** Each year hundreds of thousands of trees are lost to diseases and insects. Dutch elm disease (DED) has practically eliminated one of the most valuable trees, the American elm (*Ulmus Americana*) from the landscape. A new DED-tolerant American elm, 'Jefferson', was released in cooperation with the Department of Interior's National Park Service (the first joint release with the Park Service). Nineteen clonally propagated American elms, several American elm seedlings, and two non-American elm selections were inoculated with the fungus which causes DED, and evaluated for crown dieback; USNA American elm releases 'Jefferson', 'Valley Forge', and 'New Harmony' were found to be among the most tolerant, suffering little crown dieback. **Role:** Dr. Denny Townsend (retired 01/05) evaluated 'Jefferson' elm in collaboration with Dr. Jim Sherald, National Park Service; Dr. Townsend was responsible for inoculation and evaluation of all elms challenged with DED; selected and evaluated 'Valley Forge' and 'New Harmony'. **Impact:** 'Valley Forge' and 'New Harmony' are already widely commercially available; 'Jefferson is just beginning to become available following release in 2005. Availability of multiple superior DED-tolerant elms in the nursery trade will allow future generations to enjoy this stately tree on streets and in the landscape in numbers not seen since the spread of DED started in the 1930's.

Accomplishment: ***Creation and verification of interspecific hemlock hybrids to obtain resistance to the hemlock woolly adelgid.*** An introduced insect, the hemlock woolly adelgid, has become a very serious pest threatening the survival of both natural populations and landscape plantings of the native Eastern hemlocks (*Tsuga Canadensis* and *T. caroliniana*); many trees have been killed, and populations severely impacted. The Chinese hemlocks, *T. chinensis, T. diversifolia,* and *T. sieboldii* are highly tolerant or resistant to the woolly adelgid; interspecific hybrids were created between the susceptible Eastern hemlocks and the resistant Chinese hemlocks. Over 300 seedlings from interspecific crosses have been outplanted for field evaluation, of which about 60 have been verified as interspecific hybrids using molecular markers. Infestation of the hybrids with adelgids to test their resistance has been initiated in 2006. **Role:** Dr. Townsend was responsible for breeding of the interspecific hybrids, and collaborated with Dr. Margaret Pooler, Susan Bentz, and Louise Riedel on the molecular marker verification of the hybrids. **Impact:** The Chinese hemlock species differ in appearance from the Eastern hemlocks. Creation of interspecific hybrids should result in resistant trees with appearance similar to the Eastern hemlock for future release to the nursery industry. The Forest Service has provided grant support for clonal propagation of the hybrids for further evaluation, and there have been multiple requests for presentations on the progress of the breeding program.

Accomplishment: ***Establishment of a program to test USNA tree and shrub releases for street and utility line applications.*** Trees for street and utility line plantings face additional stresses than those used in landscape situations. Planting boxes and growing media frequently limit root growth, and street trees are exposed to additional stresses from heat, drought, de-icing salts, soil compression, and physical damage; utility line plants face additional height and volume constraints upon the canopy. Little work has been done on breeding and selection of trees specifically for these purposes, so a project was initiated to evaluate selected USNA releases in Pot-in-Pot versus traditional in-ground production, and to plant the trees out on city streets under power lines for on-going evaluation. Plants of three red maple cultivars, two elms, a flowering cherry, a crabapple, and a crapemyrtle have been compared in the two production systems, and planted out on streets in Washington DC, and Greenbelt, MD; additional plantings will follow in other locations. **Role:** This project was initiated by Dr. Hammond and Susan Bentz, with collaboration from Scott Aker (USNA Gardens Unit), and a consortium including the U.S. Forest Service, the Maryland Department of Natural Resources (MD DNR), the University of Maryland, Pepco, BGE,

Maryland Electric Reliability Tree Trimming Council, the Washington DC Urban Forestry Administration, and the Western Maryland Resource Conservation and Development Council (WMD RC&D). **Impact:** Start-up funding was provided by the U.S. Forest Service Mid-Atlantic Center for Urban and Community Forestry, and additional funding provided by MD DNR through WMD RC&D. Following the retirement of Dr. Townsend, breeding of trees specifically for street and utility line application was added to the responsibilities of the tree breeding program under Dr. Olsen, hired to replace Dr. Townsend.

Genetics, Genetic Improvement, and Improved Production Efficiency of Nursery Crops (1230-21000-042-00D)

Accomplishment: ***Developed, analyzed and utilized interspecific and intergeneric hybrids.*** Wide hybridization can expand the gene pool available for the improvement of pest resistance, environmental stress tolerance and ornamental qualities of landscape plants, but is often complicated by barriers such as embryo abortion and hybrid sterility. Three interspecific (*Hydrangea macrophylla* × *H. paniculata, H. arborescens* × *H. involucrata* and *Clethra alnifolia* × *C. pringlei*) and one intergeneric (*Hydrangea macrophylla* × *Dichroa febrifuga* and reciprocal) hybrids were produced for use in on-going breeding projects. Hybridity was verified using molecular markers and mitotic chromosome analysis. The *H. macrophylla* × *H. paniculata* hybrid was obtained by in vitro embryo rescue, and no seed were recovered from backcrosses; a chromosome-doubling approach is being attempted to restore fertility. Hybrids between *Hydrangea macrophylla* and *Dichroa febrifuga* were made in both directions, using both diploid and triploid *H. macrophylla* cultivars. Several F_2 progeny with variegated foliage were obtained from the *C. alnifolia* × *C. pringlei* hybrid, and are being evaluated for cold hardiness and commercial potential. **Role:** Dr. Reed conceived, planned and directed the research. Molecular verification of hybridity was performed by Dr. Margaret Pooler (*H. macrophylla* × *H. paniculata*), Dr. Mark Roh (*C alnifolia* × *C. pringlei*), Dr. Keri Jones (*H. arborescens* × *H. involucrata*) and Dr. Tim Rinehart (*H. macrophylla* × *Dichroa febrifuga*). **Impact**: We have shown that interspecific and intergeneric hybrids can be produced with the potential for combination of desired traits previously not available. Development of cold-hardy plants with superior ornamental characteristics will expand the area of the country in which these plants can be grown, open up new markets for the nursery industry, and provide landscapers and gardeners with more adaptable and reliable plants.

Accomplishment: ***Studied pollination biology of nursery crop species.*** Information on the pollination biology of a species is critical for carrying out an efficient plant breeding program. Self-incompatibility was evaluated in five species for which breeding projects are currently underway. A strong gametophytic self-incompatibility system was identified in *Cornus florida* (flowering dogwood). While no evidence of self-incompatiblilty acting at the stigmatic or stylar level was found in *Clethra alnifolia, S. japonicum* (Japanese snowbell) or *Lagerstroemia* spp. (crapemyrtle), self-pollinations of these species produced fewer viable seeds than did cross-pollinations. Inbreeding depression or late-acting self-incompatibility mechanisms were proposed as being responsible for the reduced seed set following self-pollinations. Self-incompatibility was documented in *Hydrangea macrophylla, H. paniculata* and *H. quercifolia* (bigleaf, panicle and oakleaf hydrangea). With the exception of *Lagerstroemia*, time of stigma receptivity was determined for all these species. Pollen from the large, showy flowers of *H. macrophylla*, which are usually referred to as sterile, were found to contain viable pollen. This pollen was as effective as pollen from the small, inconspicuous fertile flowers in controlled pollinations. **Role:** The *Cornus, Styrax, Clethra* and *Hydrangea* studies were conducted by Dr. Reed. The *Lagerstroemia* study was a cooperative project involving Dr. Cecil Pounders (USDA, Poplarville, Miss.) and Dr. Margaret Pooler. **Impact**: Knowledge of self-incompatibility and the duration of stigma receptiveness is critical for design and efficiency of breeding in these species, and will lead to an increase in the percentage of successful hybridizations. Determining that the pollen from the large, showy flowers can be used in pollinations will assist in making pollinations involving mophead forms of *H. macrophylla*, which have limited numbers of small, fertile flowers. Information that was obtained on reproductive biology of *C. florida, S. japonicum, C. alnifolia, Lagerstroemia, H. macrophylla, H. paniculata* and *H. quercifolia* will facilitate the development of improved cultivars of these nursery crops.

Accomplishment: ***Evaluated growth and performance of young transplants in nursery production.*** A major effort was made to identify inputs into nursery production systems that have an effect on optimal growth and performance of ornamental trees. Severe pruning of transplants root systems during bare root

harvest can predispose the plants to stress and subsequent borer attacks in the first year after transplanting. Infested trees are rendered unmarketable due to borer injury or outright killed after the first year in production. Flatheaded appletree borer (*Chyrsobothris femorata*) infestations, chemical control and plant response were identified with bare root maples. A color trapping method was developed to assist growers with targeting chemical spray applications by flight movement rather than calendar dates used previously. The seed source of seed-produced trees, such as oaks, can impact the growth and quality of transplants in nursery production systems. Growth performance of many seed-produced trees is often variable, and this research indicates provenance is primarily responsible. Better growth and higher quality oak transplants were obtained using known seed sources that are climatically adapted to the region of the nursery production facility. Nutrient and water usage are critical inputs to container nursery production and are of great concern when discharged into the environment. It was determined that ortho phosphate and nitrate nitrogen effluent can be reduced with cyclic irrigation as a pre-dawn application, which resulted in superior growth of container grown trees. **Role**: In cooperation with Dr. Jason Oliver, an entomologist at Tennessee State University, flatheaded appletree borer infestations, chemical control and plant response with bare root maples were studied. Dr. Fare combined efforts with Dr. Cecil Pounders, Poplarville, Mississippi, for evaluation of oaks and their seed sources. Dr. Fare conceived, planned and directed the research on nutrient and water use. **Impact**: A field survey determined infestation rates of flatheaded appletree borers (Buprestids) were 30% or more in certain species of young transplants. Using colored borer traps, Drs. Fare and Oliver showed that timely chemical applications applied as barrier treatments can reduce borer infestations and plant losses and potentially save producers about $45 million/year. Using known seed sources that are climatically adapted to the region of the nursery production facility, higher quality oak transplants can be produced by the nursery industry. Evaluation of more environmentally friendly strategies to improve the efficiency of water use, fertilizers, and pesticides in production nurseries has led to development of guidelines for environmental stewardship that are compatible with quality plant production.

Taxonomy And Genetic Diversity Assessment Of Landscape Trees And Shrubs (1230-21000-039-00D)

Accomplishment: ***Investigated the classification and relationships of species of Celtis (sugarberry, hackberry)***. Research demonstrates that species of *Celtis* subgenus *Celtis* hybridize much less readily and much less frequently than had been supposed, and that patterns of variation previously attributed to frequencies of hybridization are actually due to developmental variability and apomixis. This work is allowing the species to be delimited and characterized more naturally, and the relationships between them to be reconstructed. **Role**: Dr. Whittemore is solely responsible for the ongoing research. **Impact**: *Celtis* has great value as a landscape tree for very stressful environments. Results of this work will be used in the breeding work initiated by Dr. A. D. Townsend (USDA, FNPRU) for selecting germplasm and designing breeding experiments, and genetic markers developed for this taxonomic work have been used to evaluate Dr. Townsend's crosses.

Accomplishment: ***Revised the taxonomy of many genera and families for three major flora projects***. The *Flora of North America* is a major scientific inventory and identification manual for the vascular plants and bryophytes of temperate North America, widely considered the most authoritative source for the taxonomy of North American plants, and the *Flora of Missouri* is becoming the major manual for plant identification throughout the upper Midwest, and the *Flora of China*, an international collaboration that includes the wild ancestors and other relatives of numerous ornamental plants. Work included complex and difficult groups, including plants with promise for ornamental use and species that are or may be invasive, some of which have not been studied in decades. **Role**: Dr. Whittemore was solely responsible for most of the work. For a few, work was divided with collaborators in various ways. For study of Ulmaceae for the Flora of China, he was responsible for study and analysis of western specimens and literature, integrating the results with the work of the Chinese authors, and producing the final manuscript. **Impact**: This work is used by horticulturists, weed scientists, conservation biologists, land managers, and other plant scientists for accurate identification of plant material and for authoritative, up-to-date information on the taxonomy and biology of plants that are native or invasive in these regions.

Accomplishment: ***Developed the herbarium as a critical resource supporting research and germplasm work***. Targeted plant collection has preserved and made available plant material useful to research and introduction programs, documented plant material that is currently in cultivation in the U. S., and documented the potential for reproduction outside of cultivation by exotic plants in the United States. Databased critical holdings in the collection. **Role**: Dr. Whittemore is solely responsible for supervising this work. **Impact**: The herbarium collections and databases are a vital foundation for continued taxonomic, biosystematic, and nomenclatural work in all groups of plants. Herbarium vouchers for past and current research, breeding and germplasm exploration projects ensure that this work can be correctly interpreted by scientists, now and in the future. Databasing of critical holdings enhances the availability of the data already captured in the collection, and supports the long-term objective of making the database available on the Web and linking to GRIN and other databases.

Genetic Enhancement of Turfgrass Germplasm For Reduced Input Sustainability (1230-21000-045-00D)

Accomplishment: ***Developed genetic linkage maps of Lolium and identified genome regions useful for species seperation***. The two primary cultivated species in the genus Lolium are perennial ryegrass (*L. perenne* L.) and annual or Italian ryegrass (*L. multiflorum* Lam.). These two species are among the most important pasture/forage/turfgrass species in the world. Annual ryegrass is primarily used for forage purposes and perennial ryegrass is often used as a turfgrass. The two species are fully interfertile; however, morphologically they are quite distinct. The dramatic morphological difference between the species can lead to a reduction in turf quality when physical seed mixture or gene flow introgression result in annual ryegrass characteristics being exhibited in turf established from perennial ryegrass seed. Identifying annual ryegrass contamination in perennial ryegrass seed lots has been of major interest in seed-testing laboratories and for seed regulatory agencies for many years. United States seed regulatory agencies utilize the seedling root fluorescence (SRF) test to identify annual ryegrass contamination of perennial ryegrass seed lots. The SRF test is based on the finding that seedling roots of annual ryegrass secrete an alkaloid compound called annuloline that produces a blue fluorescence trace on white filter paper under ultraviolet light while perennial ryegrass roots do not normally show fluorescence. The gene or genes that control SRF appear to be only weakly linked to genes that result in an annual growth habit and therefore it is possible to develop perennial ryegrasses with roots that fluoresce. The potential inaccuracy of the SRF test has lead scientists to search for an alternative or supplemental test to more accurately detect annual ryegrass contamination of perennial ryegrass seed lots. **Role:** Dr. Warnke was involved in mapping population development, Amplified Fragment Length Polymorphism (AFLP) marker scoring and genetic map construction. **Impact:** This research is directed at developing species separation tests that can be utilized by the turfgrass seed industry to quickly and accurately identify ryegrass seed lot contamination. The research has identified the *Lolium* genome regions that are involved in plant morphological differences between annual and perennial ryegrass and specific separation tests are currently in testing.

Accomplishment: ***Participated in the development of Agrostis genetic linkage maps for identifying genome regions involved in disease resistance.*** A mapping population developed by Dr. Mike Casler (USDA-ARS) and Dr. Geunhwa Jung (University of Wisconsin) was established and screened using AFLP markers. A two way pseudo-testcross mapping strategy was used with markers present in one parent and absent from the other parent as well as segregating in a 1:1 ratio scored. Repulsion-phase linkages were located by analyzing the combined data set of original markers and its inverse. The computer program MapMaker was used to calculate map distances. The repulsion phase linkage analysis clearly indicates that creeping bentgrass (*Agrostis stolonifera*) exhibits preferential chromosome pairing. The AFLP data was combined with RFLP data generated by the University of Wisconsin using comparative RFLP probes and the level of synteny between *Agrostis* and other grass species in the Gramineae was determined. In addition, the genetic linkage maps have been used to identify genome regions that are influencing dollar spot disease resistance in creeping bentgrass. **Role:** Dr. Warnke generated AFLP marker data and identified the number of repulsion phase linkages to establish the genome wide chromosome pairing behavior of *Agrostis stolonifera*. **Impact:** The goal of this research is to develop Agrostis germplasm with enhanced resistance to important turf diseases and reduce overall chemical inputs. The identification of disease resistance loci is the first step towards developing new cultivars with enhanced resistance.

Genetic Improvement of Floral Crops for Pest, Disease, and Stress Tolerance and Ornamental Qualities (1230-21000-040-00D)

Accomplishment: ***Creation of new floral crops.*** New floral crops account for over 25% of floral sales, and lead expansion of the industry. Star-of Bethlehem (*Ornithogalum*) was developed as a new potted-plant crop. A series of interspecific hybrids between *O. dubium, O. thyrsoides* and *O. multifolium* were created through the use of *in vitro* embryo rescue and colchicine-induced polyploidy. Pepper (*Capsicum*) was developed as a new bedding plant. Wild and heirloom *Capsicum* germplasm was genetically recombined to create a series of hybrids with novel leaf and fruit pigmentation, as well as unique growth habits and fruit forms. **Role:** This project was a team effort involving Dr. Griesbach of the Floral and Nursery Plants Research Unit (*Ornithogalum* and *Capsicum* genetics and tissue culture), Mr. Fred Meyer of New World Plants, Escondido, CA (*Ornithogalum* collecting and breeding), Dr. Harold Koopowitz of the University of California, Irvine, CA (*Ornithogalum* taxonomy), and Dr. John Stommel of the Vegetable Laboratory, USDA-ARS, Beltsville, MD. Dr. Griesbach led the *Ornithogalum* team and was responsible for the design of the recurrent selection breeding program, as well as the analysis of the hybrids. The *Capsicum* team was co-led by Dr. Griesbach and Dr. Stommel. **Impact:** U.S. Plant Patents and Australian Plant Breeders Rights have been granted for O. 'Chesapeake Blaze', O. 'Chesapeake Starlight', O. 'Chesapeake Sunset', O. 'Chesapeake Snowflake', and O. 'Chesapeake Sunburst'. These hybrids were first sold in 2004 within the United States, Europe and Australia and are expected to become a major floral potted plant. Two *Capsicum* cultivars were released (C. 'Tangerine Dream' and C. 'Black Pearl'). Capsicum 'Black Pearl' has been selected as an All-America Selections Award Winner for 2006. Additional *Capsicum* cultivars are expected to be released in the future.

Accomplishment: ***Use of anthocyanin regulatory genes in creating new flower colors.*** Differences in flower color could be the result of either a change in pigmentation or cellular pH. There are regulatory genes that control the expression of these structural pH and pigmentation genes. In *Petunia*, a regulatory gene (*Ph6*) was identified that controlled both pH and anthocyanin gene expression. The expression of *Ph6* resulted in a lower pH and increased anthocyanin pigmentation. Another regulatory gene was identified (*PEThyb;MYB;An2*) that was quantitatively inherited. The differential control of three structural genes by *An2* resulted in a range in the intensity of flower color. A model system was created for studying regulatory gene expression. Three near isogenic lines of *Petunia* that express the *Star* mutation at different levels (high, low and intermediate expressing lines) were created. The *Petunia Star* mutation is due to anthocyanin regulatory gene silencing and results in a white star pattern in colored flowers. **Role:** Dr. Griesbach conceived, planned and directed the research. **Impact:** This research changed the thinking on how to modify flower color using either classical breeding or genetic engineering. By manipulating regulatory genes, new flower colors could be created in germplasm which lacks anthocyanin diversity. Other researchers have now cloned *Ph6* and shown it to be *PEThyb:MYC;An1* that encodes a transcription factor. The *Petunia Star* model system was used to study virus infection. When a *Star* line was infected with tobacco etch virus the silencing was released, resulting in flowers with a striped pattern of pigmentation. This release of silencing by the virus will be used to study both viral infection (Dr. Hammond) and the genetics of flower pigmentation patterns (Dr. Griesbach).

Accomplishment: ***Development of transgenic plants expressing virus resistance and to examine gene regulation.*** The Helper Component Protease (HC-Pro) genes of *Tobacco etch virus, Pepper mottle virus, Potato virus Y* and *Bean yellow mosaic virus* have each been cloned for expression in transgenic *Nicotiana benthamiana* and *Petunia*. Monoclonal antibodies (McAbs) cross-reactive with HC-Pro from several potyviruses have been developed. Single chain (scFv) antibody libraries are being engineered from these McAbs for expression in transgenic plants - in attempts to confer resistance to potyviral infection, as well as to study the mechanisms of HC-Pro gene regulation of flower color. The 3'-terminal region of *Ornithogalum mosaic virus* (OrMV) and the related potyvirus *Ornithogalum virus 3* have been

cloned and sequenced in preparation for transformation of an interspecific hybrid *Ornithogalum* using an *Ornithogalum* actin promoter isolated under another project; efforts to develop an electrophoretic transformation protocol for *Ornithogalum* have demonstrated DNA uptake but not yet stable transformation. **Role:** Dr. Hammond led the HC-Pro cloning and transformation efforts. Dr. Jordan led the HC-Pro McAb and scFv research. **Impact:** The (patented) interspecific *Ornithogalum* hybrids are horticulturally superior, but are highly susceptible to yield and quality losses from infection by OrMV and related potyviruses. Virus resistance would increase the productivity and quality of this crop, which is being sold commercially at high unit prices. Virus resistance and controlled regulation of gene regulation in *Petunia* would increase the quality of an increasing vegetatively-propagated crop. Understanding the mechanisms of viral pathogenicity and of virus resistance, and developing tools and genes for conferring virus resistance in ornamental plants, will lead to the development of better control measures and increases in both productivity and quality of ornamental plants for industry and the consumer.

Transformation For Disease Resistance In Floral Monocots (1230-21000-037-00D)

Accomplishment: ***Established an efficient regeneration system applicable to cultivars representative of three major types of roses and collaborated with scientists at Texas A&M and Sanford Scientific, Inc. to transform roses***. Transformation of roses is acknowledged to be one of the most difficult systems to achieve, and presently there is no easily reproducible regeneration system that can be applied to many cultivars of roses, although much effort continues to be expended on this important crop. **Role:** Initiated this project and wrote grants to get funding that was used to hire a part time undergraduate student for this project. Initiated embryogenic cell lines of one rose rootstock, two floribunda cultivars, and four hybrid tea roses. The frequency of regeneration was dramatically improved following isolation and culturing of pre-globular-stage somatic embryos. **Impact:** This project was funded by Roses, Inc., the commercial rose cutflower growers' association, for three years with 10-20% of their research budget. Roses, Inc. has invited Dr. Kamo to speak at their meeting, serve on their grant review board, and write articles for the Roses, Inc. Bulletin. The USDA Floricultural Initiative provided two years of funding for a postdoc to work on this project, and Dr. Kamo was invited to serve on the USDA Biotechnology Patent Committee. A Trust Fund was established with Sanford Scientific, Inc. on transformation of roses using biolistics. In January 2005 the director of research from Delbard Roses in France visited because they are using our method of regeneration. Dr. Merkle (University of Georgia) has published that our method improves regeneration for most of his American chestnut cell lines and is now being used routinely.

Accomplishment: ***Demonstrated short-term virus resistance to bean yellow mosaic virus (BYMV) in transgenic Gladiolus plants that contain either of two antiviral genes to BYMV***. *Gladiolus* ranks fifth for the number of cut flowers sold world-wide. Viruses are a major threat to quality of vegetatively propagated crops. No effective natural resistance is known. Bulbs and their cut flowers are an important export of Israel and the Netherlands. **Role:** Coordinated team research with collaboration from Sanford Scientific, Inc.; Dr. J. Hammond for antiviral constructs and initial virus challenge; and Dr. A. Gera for aphid challenge. Dr. Kamo produced the transgenic plants and performed molecular analyses for gene integration and expression. The project led to a BARD grant with the Volcani Center. **Impact:** Dutch scientists have expressed interest in developing transgenic *Gladiolus* with virus and fungus resistance using their own important cultivars. This work has led to invitations to speak as an international symposium speaker at the Korean Society for Horticultural Science Meeting, the North American Gladiolus Society Meetings, and multiple requests for articles for both the commercial *Gladiolus* growers newsletter and the N. American Gladiolus Society Bulletin. Collaboration has been established with Dr. Y.K. Chen in Taiwan for working on CMV resistance in *Gladiolus* and lilies.

Accomplishment: ***Characterized ten different promoters for their control of tissue-specific and levels of reporter gene expression in Gladiolus***. Isolated and sequenced three full-length ubiquitin promoter sequences from *Gladiolus*. Isolated, sequenced and partially characterized three Actin promoters from Ornithogalum. **Role:** Drs. Kamo and Joung were responsible for *Gladiolus* promoter isolation. Dr. Kamo developed the transgenic plants and characterized them for gene expression under various conditions. Many of the constructs used in these experiments were received from Sanford Scientific, Inc. and Dr. David McElroy at Maxygen. Drs. Maroon-Lango, Zhu, and Hammond isolated the Ornithogalum promoters. **Impact:** Promoters other than the CaMV 35S promoter must be characterized for successful commercialization of transgenic plants because of restrictions in licensing the CaMV 35S promoter. It is important to have several promoters available because more than one gene is introduced when developing transgenic plants. Scientists from South Africa, Oregon State, USDA at Florida, Kearneysville and Beltsville, and Del Monte have inquired about the results of the promoter studies in *Gladiolus*. We are collaborating with Dr. Pooler to test the *Gladiolus* ubiquitin promoter in *Prunus* because this promoter showed high level expression in roses. The results of these studies will contribute to this knowledge and the future commercialization of transgenic ornamental crops. The ubiquitin promoters from *Gladiolus*

may be useful constitutive promoters for other scientists transforming floral bulb crops, and provide information on promoter elements; there has been only one paper published on promoters isolated from a floral monocot. Isolation of this conserved promoter will allow determination of nucleotide preference in a floral monocot; deletion analysis of the promoter will determine the role of the intron and other promoter elements. A strongly, expressing constitutive promoter is needed for developing virus and fungus-resistant plants, as promoters used for cereal monocots do not give high levels of gene expression in *Gladiolus*.

Genetic Resources, Evaluation, and Information Management of Woody Landscape Plant Germplasm (1230-22000-049-00D)

Accomplishment: ***Use of molecular markers for identification and characterization of woody germplasm.*** Molecular markers generated from randomly amplified polymorphic DNA (RAPD), chloroplast DNA simple sequence repeats (cpDNA SSR), amplified fragment length polymorphisms (AFLP), and single nucleotide polymorphisms, have been utilized for characterization of *Acer, Deutzia, Clethra, Corylopsis, Ardisia, Halesia, Dendranthema, Ilex* x *wandoensis* complex, and *P. sylvestris* var. *sylvestrisformis.* Variations among *A. griseum* and *Corylopsis glabrescens* could be a result from segregation within species. Based on the presence of cpDNA SSR, *Ps* var. *sylvestriformis* appears to be an interspecific hybrid, the product of introgression involving *P.densiflora*-K and *Ps* var. *sylvestris*. Hybrid origin of *Ardisia crenata* seedlings with normal foliage (VSm) from a maternal source (VM) with variegated foliage and plant with normal foliage (WM) as a paternal source was verified by polymerase chain reaction (PCR) utilizing sequence-characterized amplified region (SCAR) markers. The paternity of open-pollinated seedlings of superior floral quality of *Ornithogalum* hybrids was determined and it was determined that superior flowers arose from cross-pollination rather than self-pollination. ***Role:*** Dr. Roh collected germplasm of *Abies koreana*, *Pinus sylvestris, P. sylvestris* var. *sylvestriformis*, *Dendranthema, Deutzia, Pinus* and *Corylopsis* in the U.S., Japan, China, Korea, Denmark and Germany. Dr. Roh directed visiting scientists for *Clethra*, *Acer*, and *Pinus*. He conceived, planned, and completed work on *Dendranthema, Lycoris, Deutzia,* and *Corylopsis.* ***Impact:*** Dr. Roh had suggested using the hybrid formula, *P. densiflora* H *P. sylvestris* for *Ps* var. *sylvestriformis* rather than an infraspecific taxon of either one or the other parental species. All *Dendranthema* germplasm was made available to Yoder Breeding, Alva, Florida, and is being used to create new forms of chrysanthemum. These SCAR markers can successfully be used to identify *A. crenata* VM progenies with non-variegated leaves involving WM as a paternal source.

Accomplishment: ***Seed germination, production, evaluation, application of new technique on*** **Styrax, Ardisia, Lachenalia,** ***and*** **Ornithogalum.** Lack of consistent and reliable seed germination of *Styrax japonicus* (Snow Bell) seeds has hindered breeding and propagation of this important woody ornamental. Dr. Roh used MRI and seed germination trials under controlled conditions to demonstrate that seeds are mature enough to germinate 12 – 14 weeks after anthesis and do not exhibit double dormancy. He showed that a high proportion of fresh mature seeds germinate within 1 month after warm stratification for 1 month followed by 2 months of cold stratification. The germination time for *Styrax* was reduced from *ca*.8 months to *ca*.4 months. An innovative production system to shorten the total cropping time for *Ardisia crenata* to less than 2 years from rooted cuttings as compared to 4 years starting from seeds were developed. Optimum floral development in *Ornithogalum dubium* hybrids occurred during bulb storage at 22^{o} - 28^{o} C as examined by magnetic resonance imaging (MRI) and scanning electron microscopy (SEM) and also by forcing experiment in the greenhouse. He further reported for the first time using MRI and SEM that malformation of florets and the inflorescence of *Lachenalia* were caused by forcing at high temperatures using bulbs that had been treated at low temperatures. ***Role:*** Dr. Roh conceived, planned, and performed *Styrax, Ardisia, Lachenalia,* and *Ornithogalum* project and wrote the manuscripts. ***Impact:*** The improved *Styrax* seed germination protocol has facilitated the *Styrax* breeding program, reducing the number of controlled pollinations needed to obtain sufficient numbers of progeny from breeding populations, and increasing breeding efficiency. Based on this work, the *Styrax* chapter in the Woody Plants Seed Manual has been revised. Growers in California using protocols based on Dr. Roh's work are now producing short stemmed *O. thyrsoides* cultivars developed at FNPRU. The first scientific publications on controlled flowering of *Lachenalia* resulted from this research and information on temperature manipulation to produce quality plants year-round will ensure the introduction and production of *Lachenalia*.

Accomplishment/role: ***Collect and conserve genetic resources and associated information for a broad spectrum of woody landscape plants and transfer technology in the form of the preceding genetic resources and associated information to researchers and breeders world wide.*** The responsibility of the Woody Landscape Plants Germplasm Repository (WLPGR) curator was changed from a Category 4 service position to a Category 1 research position in 1996 with the re-direction of Dr. Roh to this position, resulting in the development of a completely new research program as well as collection curation. In 2004, Mr. Kevin Conrad was hired as a Category 4 Service Scientist responsible for the daily operation of WLPGR activities, allowing Dr. Roh to concentrate on research activities. With the redirection of Dr. Roh to the WLPGR, germination tests of all *Pinus, Picea, Abies, Deutzia, Callicarpa,* and *Viburnum* accessions were performed to check the viability for the first time. Under Dr. Roh's and Mr. Conrad's supervision, additional germplasm was acquired, maintained, and distributed. More than 2,160 plants are maintained in the field, as well as 1,200 seeds and 830 plants in containers in greenhouse or polyhouse, from over 900 accessions representing 150 different genera. Based on the provenance trials, more than 30 superior forms of *Halesia tetraptera* var. *tetraptera* in floral size and density of floral distribution from over 500 plants (85 accessions) have been selected and propagated. Dr. Roh presented reports on germplasm accession, preservation, and distribution to the Woody Ornamental Crop Germplasm Committee (WLP-CGC) and the North American-China Plant Exploration Consortium, and established a Specific Cooperative Agreement with the American Association of Botanical Gardens and Arboreta. ***Impact:*** Dr. Roh was invited by the People's Republic of China in 2004 to explore germplasm exchange. More than 700 accessions of seeds and plants were acquired, and more than 1,300 packets of seeds and 800 cuttings and plants were distributed to the public between 1997 and 2003. More than 700 plants of Halesia and 150 plants of Cercis for the Provenance test were characterized using molecular markers. Based on the results of viability tests when seeds were stored at 5°C in a refrigerator, all seeds are now maintained at -18°C in a freezer, and new accessions are now sent to the National Center for Genetic Resources Preservation, Fort Collins, Colorado. Distribution of germplasm collected through plant exploration or exchange benefits research scientists and nursery industry through the introduction of wild germplasm to breed new landscape and nursery plants.

Biologically Based Management Strategies For Control Of Soil-Borne Pathogens Of Ornamental Crops As An Alternative To Methyl Bromide Pre-Plant Soil Fumigation (1230-22000-019-00D)

Accomplishment: ***Cloned and characterized the expression of arom gene of Rhizoctonia solani under virulent and quinate-induced hypovirulent conditions.*** Conducted gene expression, complete genomic and gene sequence analysis of the virulence-regulating shikimate pathway pentafunctional *arom* gene from the plant pathogenic fungus *R. solani*, and evaluated its phylogenetic relationships with other reported fungal and epicomplexan *arom* sequences. Part of this project (i.e, cloning, sequencing of *R. solani* arom gene and its expression under virulent and hypovirulent conditions as mediated by double-stranded RNA and quinate substrate induction) was performed at the University of Maine, Orono, Maine. **Role:** Dr. Lakshman conceived and conducted this research, analyzed and interpreted the data. Dr. Lakshman also collaborated with Dr. Stellos Tavantizis and guided a graduate student for a portion of this work while tenured at the University of Maine. **Impact:** This report constitutes the first characterization of a complete pentafunctional *arom* gene, its genome structure, its role in Rhizoctonia virulence and its regulation in a basidiomycetous fungi. In addition, this research has opened a new approach to molecularly dissecting the virulence of *R. solani*, an ubiquitous soilborne fungal pathogen of many economically important crop plants, forest trees, turf grasses and ornamentals. Managing virulence of this pathogen is the long term objective.

Accomplishment: **Evaluated abotanical formulation as an effective antibacterial agent to control soilborne bacterial plant pathogen.** A biological extract (BA), previously reported to be effective controlling soilborne fungal plant pathogens was evaluated and found to have antibacterial properties in vivo. In collaboration with Dr. Qi Huang, we found that the BA formulation controls bacterial wilt of Geranium caused by *Ralstonia solanacearum* in the greenhouse. **Role:** Dr. Lakshman conceived and conducted formulation and *in vitro* studies, analyzed and interpreted the data to demonstrate the antibacterial properties of the BA. In collaboration with Dr. Qi Huang we found that the BA could control geranium and tobacco wilts caused by *Ralstonia solanacearum* in the greenhouse experiments. **Impact:** This report should constitute as the first characterization of biocontrol properties of the BA controlling an important bacterial plant pathogen.

Accomplishment: **Screening and characterization of *Streptomyces* isolates for biocontrol of *Rhizoctonia solani* and other plant pathogens.** One hundred *Streptomyces* isolates, collected from diverse geographic locations within the United States and previously determined to be non-plant pathogenic, were screened *in vitro* for antagonism to two fungal (*R. solani* and *Fusarium oxysporum* fsp. *gladioli*) and two bacterial (*Ralstonia solanacearum* and *Xanthomonus campestris*) plant pathogens. *Streptomyces* isolates showed differing antimicrobial activities; i.e., some were anti-fungal, some anti-bacterial, and others were both anti-fungal and anti-bacterial. Antagonistic specialization was also noticed both within anti-fungal and anti-bacterial *Streptomyces* isolates. The majority of the anti-fungal isolates originated from Alaska and northeastern states like Maine and New York, whereas most of the anti-bacterial isolates came from northwestern states like North Dakota and Idaho. The ability to hydrolyze chitin has been correlated with antifungal properties. However, in-plate chitinolytic assays of the *Streptomyces* isolates demonstrated that not all anti-fungal isolates were efficient chitinase producers and some of the high chitinase producers were not anti-fungal in a dual-culture bioassay. Role: **Role:** Dr. Leslie Wanner (Vegetable Laboratory, USDA-ARS, Beltsville) collected and tested the plant pathogenicity of the Streptomyces isolates. Dr. Lakshman conceived and conducted experiments to test antimicrobial and chitinase producing activities of the isolates. **Impact:** The biocontrol potential of chitinolytic and antibiotic producing *Streptomyces* isolates, individually or in combination, will be investigated for control of *R. solani* on selected ornamental and vegetable plants in the greenhouse.

Development of Detection and Protection Technologies for Viruses and Bacteria of Major Significance to Ornamental and Nursery Crops (1230-22000-012-00D)

Accomplishment: ***Detected and characterized new and emerging viruses of ornamental plants.*** Diseases caused by viruses seriously affect the production and quality of ornamental plants. Growers have reported problems with previously unreported viruses in several economically important ornamental crop species exhibiting virus-like symptoms. Using serological and molecular technologies we have determined the identity and performed the initial characterization of several of these new and emerging viruses, and have produced reagents and tools for their detection and diagnosis. Two new potyviruses infecting the orchid *Spiranthes* have been discovered and portions of their genomes were sequenced. Three additional potyviruses, one associated with flower break symptoms in New Guinea Impatiens, another associated with leaf mosaic in *Omphalodes*, and a third from *Tricyrtis* (Toad Lily) have been discovered, partially characterized and their 3' terminal genomes sequenced. *Calla lily chlorotic spot virus* and *Calla lily latent virus* were identified in diseased *Zantedeschia* plants and shown to be new, distinct Tospovirus and Potyvirus members, respectively. Amaryllis mosaic, Lycoris mild mosaic viruses and two yet to be named Lycoris potyvirus and Bacopa ilarvirus are being investigated. A previously uncharacterized carlavirus from creeping phlox has also been completely cloned and sequenced, and characterization continues. A previously undescribed carmovirus infecting *Angelonia* has been characterized and a polyclonal antibody produced. A tobamovirus isolate infecting *Petunia* has been partially cloned and sequenced, and shown to be distinct from other characterized isolates. Other unknown or previously undescribed emerging viruses causing diseases in *Angelonia, Bacopa, Cyrtanthus, Lachenalia, Nandina, Ornithogalum, Petunia, Phlox*, and *Viola* are currently under investigation. **Role:** Dr. Jordan is investigating the *Impatiens, Omphalodes*, *Spiranthes*, *Tricyrtis*, and *Viola* viruses; Dr. Hsu is working with the *Amaryllis, Bacopa, Lycoris* and *Zantedeschia* viruses; Dr. Hammond is investigating the *Angelonia*, *Lachenalia*, *Ornithogalum, Petunia*, *Phlox*, *Nandina*, and *Viola* viruses. **Impact:** The reagents and knowledge developed aid US floriculture companies in establishing effective virus testing protocols that will improve clean stock production for new vegetatively-propagated annuals and perennials; for example, breeding programs in Angelonia were halted due to inability to detect and control the new carmovirus. The identification of these new and emerging viruses and the availability of reagents for detection will allow growers to test propagation stock in order to select healthy plants, resulting in increased productivity and quality, and customer satisfaction. Reducing losses to crops by control of plant virus diseases is the long term objective.

Accomplishment: ***Genomic characterization and transgenic resistance to viruses of importance in floral crops.*** The complete genomic sequences were determined for the following viruses: *Alternanthera mosaic virus* (AltMV), *Bean yellow mosaic virus* (BYMV), *Beet mosaic virus* (BtMV), *Elderberry latent virus* (ELV), *Pelargonium chlorotic ring pattern virus* (PCRPV), *Pelargonium line pattern virus* (PLPV), *Pelargonium ringspot virus* (PelRSV), *Pepino mosaic virus* (PepMV; two isolates), and a novel carlavirus isolated from phlox. The four viruses from geranium (ELV, PCRPV, PLPV, and PelRSV) were proposed to form a new genus, Pelarspovirus. Virus-specific monoclonal antibodies (McAbs) that detect *Carnation necrotic fleck virus* (CNFV) and *Carnation latent virus* (CarLV) were developed. Cross-reactive and serogroup-specific monoclonal antibodies were produced against *Cucumber mosaic virus* (CMV), and single chain (scFv) antibodies derived from these CMV McAbs were engineered and expressed in transgenic plants, conferring partial resistance to CMV infection. Recombinant Fab (rcFab) and scFv antibodies derived from previously developed BYMV-specific and potyvirus cross-reactive McAbs were expressed in transgenic plants (rcFab) or from a TMV viral vector (scFv). A novel biolistic inoculation method of challenging transgenic gladiolus with CMV was developed, allowing efficient evaluation of CMV resistance without laborious aphid transmissions; this method even permits challenge of gladiolus plants in tissue culture. **Role:** Dr. Hammond led work on AltMV and the phlox carlavirus, collaborating with R. Hammond on BYMV; and on BtMV with R. Hammond, L. Nemchinov, and Dr. Jordan. Dr.

Jordan headed work on the four pelarspoviruses, PepMV, CNFV, CarLV, and potyvirus rcFab and scFv antibody expression. Dr. Hsu led work on CMV antibodies and CMV biolistic challenge of transgenic gladiolus. **Impact:** Full genomic sequences permit development of infectious clones to probe virus-host interactions and symptom or host range determinants, as well as molecular reagents for virus detection and isolate differentiation, and constructs for virus resistance, aiding crop health and productivity improvement. Anti-CMV, -CNFV, and -CarLV McAbs have been provided to Agdia for use in commercial diagnostic kits. Expression of scFv antibodies in transgenic plants has been demonstrated to confer virus resistance. Biolistic inoculation significantly advances the breeding of CMV resistance in gladiolus and has applicability to other viruses and plant types. It benefits the breeding programs and growers since gladiolus is one of the economically important floral crops (with wholesale of $26,000,000 cut flower in 2002) in the United States. Understanding viral genome structures and functions, the mechanisms of viral pathogenicity, the mechanisms of virus resistance, and developing tools and genes for conferring virus resistance in plants will lead to the development of better control measures and increases in both productivity and quality of ornamental plants for industry and the consumer.

Accomplishment: ***Demonstrated for the first time the association of the fastidious bacterium Xylella fastidiosa with disorders in black oak and high-valued bonsai, and determined genetic relationships between strains of X. fastidiosa isolated from alternative hosts and from economically important agricultural food and horticultural hosts.*** By applying molecular techniques including enzyme-linked immunosorbent assay, polymerase chain reaction, and DNA sequencing, we showed for the first time the association of *X. fastidiosa* with a leaf-scorch disorder in Japanese beech bonsai and in black oak in the United States. In order to determine genetic relationships between isolates of *X. fastidiosa* from wild hosts and economically important hosts, we isolated strains of *X. fastidiosa* from alternative hosts, porcelain berry, wild grape, and mulberry, and determined their genetic relationships to isolates from economic hosts including oak and grape. We found for the first time that these alternative host strains of *X. fastidiosa* are more closely related to the oak strain than the grape strain. **Role:** Dr. Huang conceived, planned and conducted the research. **Impact:** Our finding that *X. fastidiosa* is associated with high-valued bonsai is significant because it is an important step leading to the control of the disorder and preservation of the horticultural masterpiece. It is also of great value for regulatory officials when bonsai plants are moved between countries, particularly from the United States to Asian countries where *X. fastidiosa* has not been found. Our finding that *X. fastidiosa* is associated with black oak expands the host range of the bacterium in economically important landscape tree species. Genetic and pathogenic relationships among strains of *X. fastidiosa* isolated from economically important hosts and alternative hosts in the environment were largely unknown, and greatly needed for the development of control strategies for diseases caused by *X. fastidiosa*. Our finding that porcelain berry and wild grape strains are more closely related to the oak strain than to the grape strain suggests that they may play an important role in the spread of *X. fastidiosa* affecting economically important hosts such as oak by serving as a reservoir of inoculum in nature. Suppression of these alternative host plants in the vicinity of susceptible economic hosts such as oak may be important for the control of the disease.

Technology Transfer

Floral and Nursery Plants Research Unit (general)

Research Unit Scientists have organized a scientific exhibit annually for BARC Public Field Day, attended by thousands of visitors to the Beltsville Agricultural Research Center. From 2003-2005 the exhibit was planned jointly with staff of the USNA Gardens Unit, and Education and Visitor Services Unit.

A booth presenting both recent releases and scientific highlights has been presented annually at the Southern Nursery Association Trade Show in Atlanta, GA, which is attended by about 10-11,000 visitors each year. Displays were also presented at the Tennessee Green Industries Day, McMinnville, TN (2001-2003), and for the 2001 visit of the Perennial Plant Association to the USNA.

A booth presenting information on recent releases and current research has been presented at the Mid-Atlantic Nursery Trade Show (MANTS) in Baltimore, MD (2004-2006). MANTS is attended by over 11,000 visitors.

An industry 'FNPRU Open House' was held in 2001. Presentations were also made at the Beltsville Agricultural Research Center 'Technology Showcase' (2003 and 2006), and 'Chesapeake Bay Day' (2005).

A display was presented on FNPRU research for the 'Minorities in Agriculture and Natural Resource Sciences' Field Day, 2001.

In 2001, FNPRU hosted the National Floriculture Forum, an annual meeting of primarily university floral researchers. One or more FNPRU scientists have attended the National Floriculture Forum meetings each year except 2005. FNPRU scientists have also attended the Ohio Florists Association Short Course each year except 2005, and attended various meetings of the Maryland Greenhouse Growers Association, and the Association of Specialty Cut Flower Growers.

FNPRU scientists participated in the 2003 Floriculture and Nursery Research Initiative Researchers meeting, Raleigh, NC.

Various FNPRU scientists have been interviewed for local or national print, radio, and television media outlets including Farm Radio, PBS, Home and Garden TV, etc., on research and plant releases.

FNPRU has hosted visits from: the Research Initiative Committee of the Society of American Florists (2001, 2005); Board members of the Friends of the National Arboretum (2005); and various groups through the National Visitors Center.

FNPRU scientists provided materials and participated in a practical experiments for a group of home-schooled science students (2001), and each year several high school students work with FNPRU scientists on school science fair projects (up to several hours per week). Some of these students have returned as summer interns.

Talks on research in FNPRU have been presented to groups including: the Belgian Minister of Agriculture and staff (2001); a group of Russian scientists (2001); the Patent Office, Patent Examiners Conference (2002, 2003); the U.S.-Egyptian Science and Technology Joint Board (2002); a group of

Biotechnology industry representatives from Finland (2002); a Hawaiian growers group (2002);groups of Australian and Japanese biotechnology scientists (2003); Plant Protection and Quarantine officials from Algeria, Morocco, Estonia, Latvia, Lesotho, and Senegal (2004); and representatives of the Royal Thai Embassy (2005).

FNPRU scientists have served on, and chaired, grant panels for BARD and US-AID; reviewed grant proposals for agencies including USDA, NSF, BARD, and US-AID; acted as *ad hoc* reviewers and/or on the editorial boards of a wide variety of scientific journals. The RL serves on the Scientific Advisory Board of the Fraunhofer Center for Molecular Biotechnology.

Shrub breeding

Germplasm releases:
Red-flowered crapemyrtle cultivars 'Arapaho' and 'Cheyenne' have different growth habits, but each has good resistance to powdery mildew; both were released in 2003.
'First Lady' flowering cherry has dark pink flowers, and was also released in 2003.
A highly mildew-tolerant lilac 'Betsy Ross' with fragrant white flowers was released in 2000; two additional powdery-mildew tolerant lilacs are being released in 2006 - 'Old Glory' has abundant fragrant bluish-purple flowers, while 'Declaration' has dark reddish-purple flowers.

Presented invited talks to local and regional audiences (e.g. Cornell University, Pennsylvania State University, Garden Club, Garden Writers, Landscape Architects; Southern Plants Conference) about development of new ornamental plants at the National Arboretum.

A CRADA was established with McCorkle Nurseries for development of new cultivars of several landscape plants (2002).

Initiated a Memorandum of Understanding with the Maryland Department of Natural Resources, in collaboration with the 'Biotechnology' project, and preserved and propagated the sole remaining Maryland plant of *Gaylussacia brachycera* (box huckleberry) (2001).

Distributed plants from breeding program under Material Transfer Agreements to cooperating nurseries, universities, botanical gardens, and arboreta for evaluation.

Specific Cooperative Agreements with North Carolina State University (Dr. Tom Ranney) and Oregon State University (Dr. Steve Strauss) support work on development of non-invasive woody ornamentals, funded under the Floriculture and Nursery Research Initiative (2002-2006).

Tree breeding

Germplasm release:
In collaboration with the National Park Service, released 'Jefferson', an American elm highly tolerant of Dutch elm disease (2005).

Distributed plants from breeding program under Material Transfer Agreements to cooperating nurseries, universities, botanical gardens, and arboreta for evaluation.

Participated in a workshop on the 'Urban Tree Canopy', Annapolis, MD (2004).

Provided propagation material of prior releases (red maples, American elm, hybrid elms) to commercial nurseries.

Consulted with commercial nurseries and propagators on issues related to tree propagation, and pest and disease resistance.

A Specific Cooperative Agreement with the University of Maryland supports work on evaluation of USNA tree and shrub releases for use in street and utility line applications, with funding from the Maryland Department of Natural Resources (MD DNR) through the Western Maryland Resource Conservation and Development Council (WMD RC&D).

USNA tree and shrub releases are being evaluated for street and utility line applications in Washington, DC, and Greenbelt, MD, with additional plantings planned in Hyattsville, MD, and Silver Spring, MD, in collaboration with a consortium including the MD DNR, Maryland Electric Reliability Tree Trimming Council, PEPCO, BGE, the U.S. Forest Service Mid-Atlantic Center for Urban and Community Forestry, the University of Maryland, DC Urban Forestry Administration, and WMD RC&D.

Tennessee

Attended annual trade shows of the Tennessee Nursery and Landscape Association, Middle Tennessee Landscape Association; and Southern Nursery Association; attended and participated in meetings of International Plant Propagators Society, American Society for Horticultural Science, and the Woody Landscape Plant Crop Germplasm Committee.

Hosted and presented overviews of research projects to the Tennessee State University Otis Floyd Research Crop Advisory Group (2005).

FNPRU scientists participated in presentation of various Master Gardener classes and extension workshops.

Optimum methods were developed for the storage of dogwood seed, allowing surplus seed to be stored for up to four years without significant loss of viability, thus compensating for years in which fluctuations in seed production limit availability of seedlings for rootstock production.

New cultural practices combining media amendments with microsprinkler irrigation were developed for greater water and fertilizer efficiency in container-grown trees.

Wrote articles for various trade journals (e.g. Tennessee Green Times, Landscape Plant News) and served as editors for industry newsletters (sections on research and new crops).

Presented invited talks to growers at various regional and local meetings sponsored by industry.

Distributed plants from breeding program under Material Transfer Agreements to cooperating nurseries, universities, botanical gardens, and arboreta for evaluation.

Collaborated with scientists at Tennessee State University on entomology and breeding projects, and submission of Capacity Building Grant Program proposals.

Taxonomy

Prepared various taxonomic treatments for ‘Flora of North America’, ‘Flora of Missouri’, and ‘Flora of China’.

Provided accurate plant identifications on several hundred specimens per year for external individuals and institutions, in addition to assisting other staff at USNA; provide loans and exchanges of Herbarium material with other herbaria.

Prepared digital images of all type specimens and other important holdings (including turf grasses) of the USNA Herbarium, and posted to the USNA web site for greater accessibility by other scientists.

Documented several important collections of cultivated plants as Herbarium specimens, with emphasis on USNA living collections. Several other USDA (including the Sturgeon Bay, WI potato collections) and private breeding and germplasm collections have also been vouchered to allow accurate future interpretation of current research.

Co-hosted a meeting with Russian scientists to discuss taxonomic and germplasm preservation issues, and to facilitate future germplasm collection and exchange activities.

Participated in meetings including Missouri Botanical Garden Systematics Symposia, the Smithsonian Botanical Symposia, Botanical Society of America and American Society of Plant Taxonomists annual meetings.

Turfgrass

The source code of the computer program 'Genographer', used for collection and analysis of molecular marker data from genetic analyzers, was modified to allow recognition and acquisition of data from dye labels not in use at the time the program was originally written; the original developer no longer updates the program, and prior to the modification data could not be collected using 'Genographer' from experiments utilizing primers labeled with newer dyes. The modified program has been distributed to multiple laboratories in the U.S. and abroad

DNA markers (AFLP) and gene expression (EST) data have been developed and shared with other scientists for use in the construction of a genetic linkage map of turfgrass species; ultimately the EST data will be made available on the USNA web site.

More specific DNA markers (SSR) are being developed that could be used in cultivar identification by the grass seed industry in the U.S.

Served on grant review panels for the U.S. Golf Association Research Committee.

Talks were presented at the annual Plant and Animal Genome and Crop Science Society of America meetings, and invited talks at the Rutgers Turfgrass Conference (2005) and the Molecular Breeding of Forage and Turf Conference (Wales, UK, 2005).

Specific Cooperative Agreements were established with: the University of Illinois (Dr. Andrew Hamblin; 2003-2004) for identification of *Rhizoctonia* resistance in tall fescue germplasm; the University of Wisconsin (Dr. Geunhwa Jung; 2004-2006) for mapping disease resistance genes in bentgrasses; Rutgers University (Dr. Faith Belanger; 2004-2006) for EST maker development to characterize fungal resistance in bentgrass; and Iowa State University (Dr. Shui-Zhang Fei; 2005-2006) to identify cold-regulated genes in ryegrass.

Biotechnology

Germplasm releases:
Five (5) Patent Patents were issued for hybrid Ornithogalum cultivars bred and released in cooperation with New World Plants: Ornithogalum 'Chesapeake Starlight' (PP12,850, issued 8/13/02); Ornithogalum 'Chesapeake Sunset' (PP13,154, issued 10/29/02); Ornithogalum 'Chesapeake Snowflake' (PP13,200, issued 11/12/02); Ornithogalum 'Chesapeake Sunburst' (PP13,298, issued 12/3/02); and Ornithogalum 'Chesapeake Blaze' (PP13,314, issued 12/3/02).
Capsicum `Tangerine Dream' (2003) and Capsicum 'Black Pearl' (2004) were bred in cooperation with the USDA-ARS Vegetable Lab, under a Cooperative Research and Development Agreement (CRADA) with Pan-American Seed; 'Black Pearl' was awarded the All-America Selections designation for 2006. Hemerocallis 'Chesapeake Belle' was released in 2003.

A five-partner Memorandum of Understanding (the first multi-way MOU in ARS) was initiated with the University of Delaware, two botanical gardens, and one nursery to collaborate on production of new forms of Trillium (2002).

A Material Transfer Agreement was signed with a nursery to test the commercial potential of a weeping form of purple-leaved *Cercis*.

A three-partner CRADA (the first multi-partner CRADA in ARS) was initiated with three nurseries to investigate anthocyanin genetics for application to various crops (2004).

Multiple seminars and presentations on 'Genetic engineering' and 'Anthocyanin genetics' were presented to various audiences including Master Gardener groups, plant societies, university departments, etc.

Masters and doctoral students from several universities, and students from Maryland high schools, have received training and assistance with HPLC and floral pigment analysis.

Floral Monocots

Embryogenic callus and the regeneration system for roses developed in FNPRU have been shared with a biotech company, a government agency in Korea, and scientists at Texas A&M. The regeneration system for roses has now also been applied to regeneration of American chestnut plants *in vitro*. Delbard Roses (France) is currently testing the feasibility of using the rose regeneration system for propagation of their roses.

An article on genetic engineering of gladiolus for virus resistance was published in a gladiolus society newsletter.

The transformation system for Easter lilies was developed as a cooperative project with Korean scientists under a Trust Fund Agreement (2003) with the Korean Horticultural Research Institute, and Dr. Bong Hee Han was trained in the transformation procedure during a one year stay in FNPRU as a visiting scientist.

Visiting scientists from Korea, Romania, Israel, and South Africa have been trained in aspects of tissue culture, transformation, and regeneration. Development of floral plants with resistance to cucumber mosaic virus resistance is a collaborative BARD project with Israeli scientists. Work on Ornithogalum transformation has been carried out in collaboration with South African scientists.

Woody Landscape Plant Germplasm

Germplasm collection trips to China were carried out in collaboration with staff of other North America-China Plant Exploration Consortium (NACPEC) member institutions; the germplasm collected was shared between the participating NACPEC institutions, and with other botanical gardens and arboreta as available.
Hosted the 2002 NACPEC meeting.

Seed and vegetative propagations from WLPGR accessions were distributed in response to requests, either through the Germplasm Resources Information Network (GRIN) or directly to WLPGR staff, from gardens, arboreta, nurseries, and research institutes in the United States and other countries. In 2005, a total of 296 germplasm accessions were distributed to groups and individuals.

Methods for the efficient vegetative propagation of quality plants of *Ardisia crenata* were published and made available to growers; these methods shorten the juvenile period before plants produce the ornamental berries that have commercial appeal in a container-grown plant.

Methods were developed for non-destructive evaluation of maturity of *Styrax* seed, and for significantly reducing the time required for germination (with a chapter in the Woody Plants Seed Manual). These methods have aided the *Styrax* breeding program of Dr. Reed at McMinnville, as well as benefiting nurserymen commercially raising plants from seed.

A Specific Cooperative Agreement was initiated (2001-2006) with the American Association of Botanical Gardens and Arboreta, to work collaboratively with the North American Plant Collections Consortium (NAPCC) to curate and document wild-collected germplasm of woody landscape plants. Through this collaboration the WLPGR will play a role in preservation and documentation of more germplasm than can be physically managed within the Repository. Participated in NAPCC Curator training workshops (2004, 2005).

Methyl Bromide Replacements

Results from laboratory soil assays, greenhouse seedling bioassays and field mini-plots have been presented at scientific meetings and shared with private sector cooperators. The progress toward developing alternative management strategies, specifically environmentally friendly biopesticides, has been presented to extension personnel and specialists during in-service training sessions. The constraints to the development of this technology are the partnership development with registrants of these biopesticides and the successful demonstration of disease control in commercial growing situations.

Communicated with scientists in India, and MD, ME, and NC on issues related to *Rhizoctonia*.

IR-4 (Project terminated by National Program Staff 9/05)

Between 44-80 projects per year were carried out to evaluate phytotoxicity and efficacy of insecticide, fungicide, and herbicide products on a variety of ornamental crops. Data collected through these projects was compiled annually and forwarded to the registrants for inclusion in label expansion applications to the Environmental Protection Agency. Label expansions make weed, pest and disease control products available to nurseries and homeowners.

Entomology (Project terminated after scientist left 3/05)

Nitrogen fertilization was shown to increase the susceptibility of red maples and Freeman maples to oviposition and damage caused by the potato leafhopper. Leaf flush phenology was shown to be a significant factor in susceptibility to the potato leafhopper, with cultivars that leaf out and develop mature leaves earliest suffering the least damage.

Several leafhopper species were identified as vectors of *Xylella fastidiosa*, the causal agent of bacterial leaf scorch of shade trees. Identification of these vectors is important for development of potential control strategies.

Pathology

FNPRU scientists participated and presented reports at an annual discussion session on virus diseases affecting ornamentals with industry and representatives and university scientists, during the American Phytopathological Society meeting. Additional discussions have occurred via conference calls.

FNPRU scientists organized, hosted and participated in the NE1006: Eradication, Containment and/or Management of Plum Pox Disease (Sharka), Plum Pox Virus (PPV) Meeting held December 12-14, 2004 at Beltsville, MD. This meeting, entitled "Plum Pox Virus in North America: Five Years Later", was attended by domestic and international researchers, agency regulators and grower/nursery groups. FNPRU scientists also participated in PPV meetings from 1999-2003 following the discovery of PPV in Adams County, PA; the initial finding of PPV was confirmed using the FNPRU-developed monoclonal antibody PTY 1 (patented and licensed to Agdia).

FNPRU scientists organized, hosted, and participated in the 10th International Symposium on Virus Diseases of Ornamental Plants, held in Annapolis, 2000; participated in the 11th Symposium held in TaiChung, Taiwan, in 2004, with invited presentation ‘Current Status of Genetically Modified Ornamentals’; and continue to serve on the committee of the Working Group on Virus Diseases of Ornamental Plants.

The RL served on the Environmental Protection Agency FIFRA Scientific Advisory Panel on “Issues Associated With Deployment Of A Type Of Plant-Incorporated Protectant (PIP), Specifically Those Based On Plant Viral Coat Proteins (PVCP-PIPS)” (2004); and was an invited participant in meetings on “Public Research and Regulatory Review of Small Market Biotech Crops” (2004) and the “Specialty Crops Regulatory Initiative” (2005).

A display describing current research, and practical demonstrations of the rapid detection of plant viruses, was presented at the Mid-Atlantic Nursery Trade Show in Baltimore, MD (2005).

Seminars and workshop-labs for Howard County schools entitled "Biotechnology and Plant Viruses" were presented to the 'Biotechnology Junior Practicum', at the Applied Research Labs, Columbia, MD (2002-2005).

CRADAs and Trust Fund Agreements have been established with Agdia, Inc. for work on developing diagnostic reagents for viruses affecting ornamental crops. Purified viruses have been provided for preparation of virus-specific antisera, or in other cases the antisera themselves have been provided. Collaborative research has included sequencing and characterization of *Pepino mosaic virus*; and in collaboration with Scott Adkins (USDA-ARS, USHRL, Fort Pierce Florida) and Abed Gera (the Volcani

Institute, Bet Dagan, Israel), sequencing, characterization, and antiserum production to *Angelonia flower break virus*, a new carmovirus.

Invited American Phytopathological Society 'Hot Topics' presentation 'Public Discussion of Plant Pathogens as Bioweapons' in Symposium 'Information Security versus Freedom of Information in Agriculture (2004).

Invited talk on 'Plants as bioreactors and the potential of plant pathogens as bioweapons' to defense analysts in a course on Chemical and Biological Warfare Proliferation (2005).

Invited participation in the Indo-U.S. Interactive Workshop on Plant Molecular Virology, New Delhi, India (2006).

Participated in USDA-APHIS working group meetings on *Ralstonia solanacearum* Race 3 biovar 2 (2004).

Visiting scientists from Italy and Israel, and students from the Solomon Islands and Maryland high schools have received training.

Provided information on Pepino mosaic virus to scientists from Canada, New Zealand, and the U.S., and exchanged information through presentation at the Tomato Breeders RondTable Workshop, Annapolis (2004).

Communicated and collaborated with scientists in England, CA, FL, KY, MD, NJ, OR, WI, and Washington DC on bacterial disease problems.

Communicated and collaborated with scientists from Austria, Brazil, England, India, Israel, the Netherlands, New Zealand, Peru, and AZ, CA, DE, GA, IN, MD, NC, OH, OR, PA, and WA on various virus-related problems.

Responded to various nursery industry queries about specific virus problems affecting ornamental crops, and especially pansy mottle syndrome (nurseries in GA, MD, MI, MN, NC, PA, TX, WV, MI).

Multiple sequences of plant viral genes and genomes have been deposited in GenBank, including the complete genomic sequences of isolates of *Alternanthera mosaic virus*, *Bean yellow mosaic virus*, *Beet mosaic virus*, *Pepino mosaic virus* (two isolates), and *Pelargonium chlorotic ring pattern virus*, and partial sequences of multiple other virus. In addition partial gene sequences of several strains of *Xylella fastidiosa*, and sequences of the light and heavy chains of several plant virus-specific monoclonal antibodies have been deposited.

Specific Cooperative Agreements were established with: the University of California-Riverside (Dr. Allan Dodds; 2002-2006), Oregon State University (2002-2006), and Ohio State University (Dr. Steven Nameth; 2002-2006) for work on diagnosis and control of viruses affecting ornamentals; and with the University of Wisconsin (Dr. Caitilyn Allen, 2003-2006) and the University of Florida (Dr. David Norman; 2003-2006) on *Ralstonia solanacearum* Race 3 biovar 2.

Future Research Plans

Shrub breeding: Future research will focus on continuing the efforts to evaluate, breed, and release improved landscape trees and shrubs that are disease and pest resistant, tolerant of environmental stresses, are not invasive, and are of superior ornamental value. This research will be achieved by: 1) genetically characterizing and evaluating the horticultural merit and stress resistance contained in the germplasm and advanced selections of *Cercis, Corylopsis, Halesia, Lagerstroemia, Prunus, Syringa,* and other genera. 2) developing new or improved genetic marker systems for assessing genetic diversity and accelerating genetic improvement of these genera. 3) incorporating improved disease and stress resistance and ornamental traits into this germplasm using traditional and new breeding methodologies. 4) transferring superior landscape plant cultivars to the end users.

Tree breeding: 1) To continue the hemlock breeding program to develop interspecific hybrids with appearance similar to the Eastern hemlocks, combined with resistance to the hemlock woolly adelgid. 2) To continue the *Celtis* breeding program begun by Dr. Townsend, in order to develop superior trees resistant to insects and mites. 3) To evaluate existing USNA releases and promising selections, and to initiate a breeding program for smaller trees specifically for application in street and utility line plantings; these are applications requiring trees resistant to pests, diseases, and diverse environmental stresses, for which the tree breeding program at the USNA is well suited; to our knowledge no significant breeding effort towards these goals are occurring elsewhere.

Tennessee: 1) Continue on-going breeding projects involving the development of cold hardy hydrangeas with blue flowers; disease resistant, remontant *H. macrophylla*; compact *H. quercifolia* and *C. alnifolia* germplasm with improved floral characteristics; *Styrax japonicum* germplasm with delayed budbreak and unique ornamental traits; cold hardy *Clethra* with ornamental foliage; and disease resistant flowering dogwood. 2) Determine inheritance of disease resistance and ornamental traits in *Hydrangea* and *Cornus*. 3) Produce additional *Hydrangea*, *Clethra* and *Cornus* interspecific hybrids. 4) Evaluate inbreeding depression in *Hydrangea* and *Clethra*. 5) Continue studies with transplant stress and survivability of bare root liners. 6) Determine carbohydrate loading and storage ability of several ornamental plants prior to fall dormancy and harvest, and the subsequent impact on transplantability. 7) Develop production strategies to reduce the use of water, fertilizers, and pesticides in production. 8) Conduct studies of vegetative propagation methods for underutilized and difficult to propagate plants such as serviceberry (*Amelanchier*), sourwood (*Oxydendron*) and oaks (*Quercus*). 9) Evaluate the ornamental merit, disease and insect resistance, and stress tolerance of landscape plants, such as camellia (*Camellia*), crapemyrtle (*Lagerstroemia*) and oaks (*Quercus*).

Taxonomy: 1) Assess systematic relationships and the amount and apportionment of genetic diversity within and between species in the genera *Celtis* and *Quercus*, using morphology, DNA sequencing, AFLP and SSR techniques to develop genetic markers that will facilitate this work and at the same time be useful for breeding and selection work in these genera. 2) Manage and develop the National Arboretum herbarium, the only large herbarium in USDA focused on cultivated plants and their wild relatives; expanding our database, making it available online, and linking our germplasm vouchers to their records in GRIN is a priority. 3) Collaborate in the documentation of emerging invasive woody plants, and the investigation of traits contributing to their invasiveness. 4) Work to determine the valid botanical and cultivar names for landscape trees and shrubs, and to ensure that those names are properly and consistently applied.

Turfgrass: 1) Establish *Festuca* and *Agrostis* EST-SSR allele size ranges and develop multiplex sets to improve throughput for cultivar identification, genetic diversity analysis and genetic map development. 2) Initiate wide crossing efforts with *Festuca* and *Lolium* germplasm and develop procedures for embryo

rescue in collaboration with Dr. Bughrara at Michigan State University. 3) Continue recombinant inbred (RI) line development in *Lolium* using both inbreeding and anther culture and begin mapping F2 populations developed from inbred parents. 4) Begin screening Fescue-Lolium wide cross hybrids for improved abiotic stress resistance in collaboration with Dr. Bughrara at Michigan State University. 5) Begin mapping F2 generation of RI *Lolium* mapping population and *Agrostis* mapping populations segregating for phase change using AFLP, EST-SSR, and RFLP markers and identify genome regions influencing phase change.

Biotechnology: The expression and control of structural and regulatory genes responsible for organ specific anthocyanin pigmentation in *Capsicum* will be studied. *Capsicum* germplasm with novel foliage color will be released through a CRADA. The expression and control of structural and regulatory genes responsible for virus induced flower-break will be studied. The level of tobacco etch virus expression in infected Star *Petunia* will be compared to the level of anthocyanin accumulation to determine if the concentration of virus in a section of tissue corresponds to concentration of anthocyanin. Once this is determined, the level of tobacco etch virus expression in infected Star *Petunia* will be compared to the level of expression of different anthocyanin genes expression to determine which anthocyanin gene is affected by the virus. Transgenic floral crops exhibiting induced resistance to selected major viral diseases will be developed. Model plants will be transformed with constructs designed to induce effective RNA silencing of *Ornithogalum* mosaic virus (OrMV) prior to transformation of *Ornithogalum*. The effectiveness of RNA silencing will be determined by challenge with potexviral vectors carrying OrMV sequences. Constructs designed to confer resistance to multiple viruses will be tested. Key "model" ornamental plants will be transformed with various anti-viral scFv constructs to evaluate this novel antibody-based form of engineered anti-viral resistance.

Floral monocots: 1) Evaluate methods of gene silencing, such as RNAi, to suppress viral pathogen propagation in floral monocots, and develop gene silencing-based viral resistance in *Gladiolus* and lilies. 2) Evaluate and optimize genetic transformation technology, including regulatory elements such as promoters, for improvement of disease resistance and other important horticultural traits of floral monocots, emphasizing Easter lilies. A. Genes involved in nematode development will be isolated and tested for their ability to inhibit the growth of *Pratylenchus penetrans* using RNAi. Promising candidate genes will be used for transformation of Easter lily and tested for their control of *P. penetrans*. B. Test the effectiveness of a variety of antifungal genes in conferring resistance to *Fusarium*. Evaluate effectiveness of genetic transformation in comparison to other pesticide-sparing control strategies, such as biocontrol.

Woody Landscape Plant Germplasm: Repository activities - 1) Continue forward with the planned move from Glenn Dale to South Farm in Beltsville, Maryland as well as putting a greater emphasis on incorporating the USNA D.C Campus for collections preservation. 2) As a high priority for the WLPGR, establish a domestic (U.S.) collections program targeting collectors who are actively collecting but not preserving their collections in long term *ex situ* programs. 3) Continue collaborating with the American Public Garden Association (APGA) in the continued growth and development of the North American Plants Collections Consortium (NAPCC). 4) Establish ties with germplasm collections in Japan to document the declining wild populations in that country. 5) Actively seek and collect new germplasm with a focus on the Russian Far East, the trans-Caucasus region including the Republic of Georgia, Armenia and Azerbijan. 6) Link the WLPGR regional collaborators and their collections to the Web site of the U.S. National Arboretum. 7) Continue collaboration with the North American China Plant Exploration Consortium (NACPEC) on additional germplasm from China.

Research activities - 1) Seed germination of *Styrax, Corylopsis,* and *Nandina* - MRI with *Styrax* and uniform and accelerated germination with *Nandina* as influenced by seed harvest date, plant growth regulators, and storage temperatures. 2) Vegetative propagation and overwinter loss of *Styrax* as

influenced by stem length and the time of propagation. 3) Evaluation of *Halesia* (floral characteristics), *Deutzia* (floral characteristics), and *Abies* and *Pinus* (heat tolerant characteristics) germplasm. 4) Characterization of *Abies, Camellia, Corylopsis, Halesia,* and *Ilex,* using molecular markers generated by ISSR, RAPD, RFLP, and SSR microsatellite techniques. 5) *Ex situ* conservation and genetic purity study with *Abies* and *Pinus* affected by hybridization. 6) Development of cold hardy molecular markers in *Camellia*.

Methyl Bromide Replacements: 1) Investigate, develop, characterize and use hypovirulent isolates for the control of soil-borne pathogens causing damping-off and stem rot diseases in ornamental crops, with emphasis on *R. solani*. 2) Explore and develop organic amendments and biorationals for the management of soil-borne pathogens inducing damping-off and stem rot diseases in ornamentals with emphasis on *R. solani*. 3) Investigate the effectiveness of microbial antagonists in combination with reduced risk pesticides in the management of *R. solani* and other soil-borne fungal pathogens.

Pathology: 1) Continue to investigate and characterize viruses of major significance to ornamental and nursery crops (annuals, perennials, woody ornamentals, bedding plants, and bulb crops), including, but not limited to: potyviruses (including plum pox virus), tospoviruses, fabaviruses, pelarspoviruses, potexviruses, carlaviruses, closteroviruses, cucumber mosaic virus, arabis mosaic virus, and "new" currently uncharacterized or emerging viruses affecting key ornamental crops. 2) Develop serological reagents, molecular probes and diagnostic technologies for the detection and management of diseases caused by the viruses listed above. 3) Determine the genome organization of selected important ornamental viruses and develop full-length infectious clones to determine the genes or gene products involved in pathogenicity and their mode of action. 4) Develop and utilize anti-viral and anti-bacterial genes in the production of transgenic floral crops exhibiting induced resistance to selected major viral and bacterial diseases. 5) Identify and develop alternative plant expression promoters. 6) Conduct research on the host range, epidemiology and non-pesticidal control of bacterial wilt disease of geranium caused by *Ralstonia solanacearum* race 3. 7) Develop knowledge and tools for the detection and control of bacterial leaf scorch disease of woody ornamental crops caused by *Xylella fastidiosa*. 8) Characterize the genome of ornamental strains of *X. fastidiosa,* their relationships with hosts and vectors, and develop methods for disease control.

Proposed New Research Initiatives

The Floral and Nursery Plants Research Unit is in a unique position because of the integration of germplasm and breeding activities within a single group at the same location. The national role of the U.S. National Arboretum would be enhanced by expansion of these activities, as the premier national institution for ornamental plant breeding and plant improvement. This would involve not only FNPRU, but would further strengthen existing interactions with the Gardens Unit, and utilize the capabilities of the USNA web site and the Education and Visitor Services Unit to aid in transfer of information and technologies to other researchers, the industry, and consumers.

Four broad areas are envisioned to contribute to an expanded ornamental improvement program:

1. Tree, shrub, perennial plant and turf breeding and improvement. A comprehensive program with additional scientists and support staff would utilize and build upon the existing strengths of the Woody Landscape Plants Germplasm Repository, the living plant collections of the Gardens Unit, the existing breeding collections of the Trees, Shrubs, McMinnville, and Turf CRIS projects, and the research support of the USNA Herbarium and Taxonomy CRIS. Expansion of the existing tree and shrub breeding programs, and addition of perennial breeding would result in release of more superior plants to the industry. Addition of a turf pathologist would complement current turfgrass breeding efforts. Collaboration with the Pathology, Biotechnology, Floral Monocots and Methyl Bromide Replacements

CRIS projects would provide research support to develop plants with resistance or tolerance to biotic and abiotic stresses, through approaches such as wide hybrids, embryo rescue, molecular markers to identify and track integration of genes, and biotechnology. Integration of production technology and practices such as container design, methods for fertilizer and water application optimization, and treatments or biocontrol agents to minimize disease in production will increase production efficiency and environmental stewardship. Additional research expertise in entomology, stress physiology and above-ground fungal pathology would further complement this research thrust and create a fully integrated program.

2. Further development of the Woody Landscape Plant Germplasm Repository and extended collaboration with the North American Plant Collections Consortium (NAPCC) program of the American Public Gardens Association (APGA) would enable us to increase the level of germplasm acquisition activity, and to ensure the preservation and characterization of a broader representation of woody plant germplasm for future utilization and habitat restoration. Additional scientists in-house would utilize DNA markers and other techniques to determine the genetic diversity of accessions both in the WLPGR collection and those of associated NAPCC collections. Additional support staff for plant propagation and evaluation, and to manage the collections and conduct plant exploration, would support the activities of the WLPGR at both the Beltsville and Washington, D.C. locations. Additional resources would allow the WLPGR to expand both domestic and international germplasm collection efforts, and to aid the introduction of more accessions from the Repository into the nursery industry.

3. To coordinate production of an on-line Flora of the Cultivated Plants of North America to document the wide variety of materials available throughout the industry. This would be a major undertaking that would extend beyond current efforts to increase the USNA Herbarium holdings of cultivated ornamentals. The Checklist of Cultivated Plants of the Southeast United States that was produced a few years ago would serve as a starting point for this effort, with specific genera of cultivated plants such as *Pelargonium*, *Narcissus*, and *Hydrangea* initially targeted for herbarium collections. The USNA would take the coordinating role to form a consortium of other institutions (university departments, botanical gardens and other arboreta) to take on this important major task. Additional resources and personnel would be required for the FNPRU taxonomy program to take on such a significant undertaking. Such an undertaking would also benefit other researchers, the industry, and consumers.

4. A recent Urban Horticulture Initiative in collaboration with the Gardens Unit of the USNA, if funded, would address a group of interlinked problems related to urban plantings, including: 1) plant selection (additional tree and shrub breeding); 2) stress physiology, to work on screening protocols to identify germplasm accessions and selections tolerant to multiple biotic and abiotic stresses (in collaboration with the tree and shrub breeders, pathologists, entomologist, and horticulturists); and 3) fungal pathology of woody plants - to address such problems as *Phytophthora* vascular wilts, dogwood powdery mildew, dogwood anthracnose, *Botryosphaeria* canker, and the many leaf spots and diebacks that affect trees and shrubs. Additional positions or problems to be addressed through the Gardens Unit under the same initiative include a technology transfer/arborist specialist; an entomology/IPM specialist; and a soil scientist/environmental engineer to work on problems associated with tree boxes, soil compaction, and water quality issues affecting urban tree plantings.

Position Staffing Plan – Pages 56-57:

These were not available for this web-based PDF version.

Position Category Codes

An ARS system of administrative designations for groups of positions having generally similar characteristics, primarily for personnel and budgetary tracking purposes. Category has no legal or administrative significance outside of ARS. Some positions may perform duties from more than one category. ARS categories established for all positions are as follows:

- **Category 1 (Research Scientist).** Permanent positions in which the highest level of work, for a major portion of time, involves personal conduct or conduct and leadership of theoretical and experimental investigations primarily of a basic or applied nature such as: determining the nature, magnitude, and interrelationships of physical, biological, and psychological phenomena and processes; creating or developing principles, criteria, methods, and a body of knowledge generally applicable for use by others. Such positions meet all or most of the criteria enumerated in the RGEG. Category 1 positions are SY positions.

- **Category 2 (Nonpermanent Research/Service Scientist).** Professional scientific positions which are established on a nonpermanent basis, are filled through temporary or term appointments, and entail research and/or service science work. Examples are Research Associate, Research Affiliate, Visiting Scientist, and individuals reemployed in ARS after having retired from Category 1 or Category 4 positions. *(Except those appointed as Collaborators -- see Code 0.)*

- **Category 3 (Support Scientist).** Professional scientist positions which function to provide direct support or service to one or more Category 1 or 4 positions. The work of such positions is characterized by responsible involvement in one or more, but not all, phases of research (particularly not the problem selection and definition phases); responsible participation in analysis and preliminary interpretation of data (but not including responsibility for final interpretation and conclusion which relate the results to the field of research involved). Examples include but are not limited to: (1) conducting literature searches; (2) selecting procedures and conducting experiments; (3) collecting and analyzing data or specimens; or (4) preparing technical reports.

- **Category 4 (Service Scientist).** Permanent positions whose incumbents either primarily or exclusively serve as project or program leaders over or personally perform, work assigned to ARS involving professional scientific services to the public or other governmental agencies, such as: identification of animals, plants, or insects; diagnosis of diseases; mass production of plants, animals, or insects, collection, introduction, and maintenance of germplasm or specimens; vaccine production; education, extension, or technology transfer activities; or nutrient data and food intake surveys. Category 4 positions are SY positions.

- **Category 5 (Technician/Aid/Assistant (Non-engineering and Non-scientific).** Includes all technicians, aids, and assistants in non-engineering and non-scientific single-interval occupational series (except those within the GS-0300 Group). Examples include: Safety Technician, Personnel Assistant, Accounting Technician, Purchasing Agent, Procurement Assistant, Library Technician, Supply Clerk, Personnel Clerk, Photographer, Guard, Firefighter.

Position Category Codes Continued

- **Category 6 (Specialist).** "Specialist" positions which perform scientific program management, administration and/or analytical duties and therefore require professional education and training. Examples are: Area Director, Center Director, Agricultural Administrator, National Program Leader, Human Resources Specialist, Information Technology Specialist, Administrative Officer, Budget Officer, and Librarian.

- **Category 7 (Technician/Aid/Assistant positions (Engineering and Scientific Support).** Identify technician, aid, and assistant positions in one-grade interval series within the GS-400, 600, 700, 800, 1300, and/or 1500 groups. Examples include: Biological Science Technician/Aid, Electronics Technician, Hyrodologic Technician, Statistical Assistant/Clerk, Physical Science Technician.

- **Category 8 (Trade and Craft Occupations).** Positions having trade or craft knowledge as the paramount qualifications requirement. Examples: Boiler Plant Operator Foreman, Animal Caretaker Leader, Laborer, Farmer, Tractor Operator.

- **Category 9 (Administrative Support Occupations (Clerical/Secretarial/Other).** General occupations involved in structured work in support of office operations within one-grade interval series in the GS-300 occupational group. Examples: Secretary, Office Automation Clerk/Assistant, Computer Operator, Administrative Technician/Clerk, Management Assistant/Clerk.

- **Category 0 (Zero).** Includes all positions that do not fit any of the above codes, including all positions incumbered by students. Examples: Student Trainees (STEP, SCEP); Expert and Consultant positions; Collaborators; and Volunteers.

- **Category G (Intergovernmental Personnel Act (IPA).** Employees serving a temporary assignment between ARS and States, local governments, institutions of higher education, Indian Tribal governments, or other organizations under Title IV of the Intergovernmental Personnel Act of 1978 (PL 95-454).

FNPRU and USNA Budget Information – Pages 60-65:

These were not available at the time of production of this web-based PDF version.

Please see budget information with each respective CRIS on pages 11-26.

Update to In-Depth Review Report
Floral and Nursery Plants Research Unit
U.S. National Arboretum, Beltsville Area

The response to the Panel's In-Depth Review Report of the Floral and Nursery Plants Research Unit (FNPRU) following the August 31 – September 2, 1998 review was prepared by Dr. Thomas S. Elias on January 5, 1999. The following is updated information. The Panel's report and Dr. Elias' 1999 response are attached to this update.

1. Recommendation:

We were impressed with the excellent transgenic work on *Gladiolus*. The accomplishments achieved in collaboration with scientists from South Africa and Korea in producing transgenic *Ornithogalum* and lily plants indicate this research on monocots is truly outstanding. We would encourage more efforts be directed to this project.

Update:

Significant progress has been made in further transformation of lily and *Gladiolus*.The FNPRU is working with the Nematology Laboratory to identify genes for nematode resistance.

2. Recommendation:

Research on transgenics for virus control should be more focused as to be able to investigate mechanisms with broad applicability rather than a perceived need to avoid intellectual property issues.

Update:

Most work has been concentrated on CMV resistance in *Gladiolus* using promoters from other sources, replicase and coat protein genes from external sources, and antibody constructs derived from in-house monoclonal antibodies. There would have broad applicability. Other efforts continue on *Ornithogalum* mosaic virus.

3. Recommendation:

The initiation of research on promoters should be continued since funding has been obtained for this investigation. It is recommended that promoters held by universities or other sources of licensable promoters not be excluded.

Update:

Promoters from *Ornithogalum* and *Gladiolus* have been developed inhouse, and ten (10) promoters from external sources have been evaluated.

4. Recommendation:

The Panel recommends that the entomological focus should be on pests of woody ornamentals. The Panel noted that it was not apparent that suitable isolation spaces were available to conduct entomological research.

Update:

The entomologist left for another position in early 2005 and entomology as a separate program has been terminated, with resources applied to related pathology and tree breeding programs. The insect rearing chambers will be utilized in support of the pathology program to examine vectors of bacterial and viral diseases, and in conjunction with the tree breeding program for evaluation of insect resistance in trees and shrubs.

5. Recommendation:

The Panel also noted that the research of the methyl bromide CRIS project should be conducted regardless of the legal status of methyl bromide. The Panel also encourages Dr. Locke to pursue long-term interests that would elucidate mechanisms or other fundamental aspects related to the identification and utilization of natural products for pest and pathogen control.

Update:

Dr. Dilip Lakshman was hired to replace Dr. James Locke for the Methyl Bromide replacements and IR-4 programs. The FNPRU part of the IR-4 program was terminated by the National Program Staff effective September 30, 2005.

6. Recommendation:

It is recommended that the new pest-resistant trees developed by staff be released to more industry propagators so that they can be made available more quickly. It is also recommended that intellectual property rights be sought for these new introductions, and that mechanisms be established to ensure that royalties be collected and returned to the breeding programs to help offset future research costs.

Update:

An arrangement with the Horticultural Research Institute of the American Nursery and Landscape Association is being expanded to result in protection and more effective release of newly-bred trees to the industry. However, the extensive evaluation of the U.S. National Arboretum (USNA) releases contributes to their standing in the industry, and the evaluation period should not be compromised solely for faster release.

7. and 8. Recommendations:

The Taxonomist position should be filled by a broadly trained systematist with excellent organizational and leadership skills and at a salary level commensurate with the broad responsibilities of this position. The USNA has an opportunity to fill an important national need

by serving as a national clearing house for information on cultivated plants both by providing information on available taxonomic expertise and by undertaking coordination of a collaborative Garden Flora of North American (or a Manual of Cultivated Plants). Such a project would have national impact.

The Herbarium should be aggressively expanded through exchange and field collecting; in addition, ancillary collections could be established, e.g., of plant material stored in silica gel to be used for molecular analysis. The Herbarium should continue to be the repository for vouchers or ornamental germplasm and of all living collections in the Arboretum grounds and at the Woody Landscape Plant Germplasm Repository. The USNA should become a national clearing house and repository for information on ornamental plants. It must capitalize on the strength of its Herbarium as one of the largest and most important collections of ornamental plants and their wild relatives.

Updates:

Dr. Alan Whittemore was hired and has made significant advances in:
1) increasing the representation of USNA collections and other Agricultural Research Service collections in the USNA Herbarium; 2) adding to the collections from Russia, and establishing collaborative agreements; and 3) all of the Herbarium type specimens and many other important specimens have been digitally imaged and posted on the USNA Web site.

9. Recommendation:

Staff should be encouraged to travel to and present their research findings at both trade and professional meetings to interact and collaborate with colleagues within ARS and at land-grant universities.

Update:

A booth has been presented annually at the Southern Nursery Association trade shows, and for the last three years at the Mid-Atlantic Nursery Trade Show (MANTS). The pathologists participate in an annual discussion session on ornamental viruses at the American Phypathological Society Annual meeting and in conference calls with various industry representatives. In 2001 the FNPRU hosted the National Floriculture Forum.

10. Recommendation:

We recommend the establishment of standing panels to provide counsel and oversight on industry needs and scientific merit of research programs.

Update:

The FNPRU has hosted visits of the Society of American Florists and the American Nursery and Landscape Association initiative committees, and the Research Leader and scientists have visited with major nurseries in conjunction with other travel.

11. Recommendation:

We recommend that the Unit conduct an open house at least biennially. They should consider directing their attention to the industry one year and to the academic community in alternate years.

Update:

An open house was held in September 2001 and an informal open house immediately precedes the in-depth lab review on May 9, 2006. In addition, the FNPRU has participted in the annual Beltsville Agricultural Research Center Field Day, the Southern Nursery Association trade show, and the Mid-Atlantic Nursery Trade Show.

12. Recommendation:

The Station (BARC) administration should be made aware that the landscaping and overall condition of the exterior grounds surrounding the laboratory building (010A) was an embarrassment and efforts should be made to maintain a landscape that reflects a positive image of this important national resource.

Update:

Some USNA releases were planted by the parking lots in front and behind Building 010A. The transition to the Most Efficient Operation (MEO) has reduced the ability of the grounds staff to install and maintain plantings.

13. Recommendation:

The Panel strongly urges that the Glenn Dale facility be maintained for research and living collections of the woody perennial plants. The current site has proper soil, an irrigation system that serves the entire facility, and is at least partially fenced to exclude deer.

Update:

The South Farm location of the Woody Plant Germplasm Repository is quite well established, and additional germplasm has been planted on the grounds of the USNA including in association with the Flowering Tree Walk.

14. Recommendation:

The Panel detected a need for bacteriology expertise in the group. We recommend the addition of a bacteriologist as it is perceived as a significant deficiency in expertise in this broad-based group.

Update:

Dr. Qi Huang was hired in 2001 and has established a program on *Xylella fastidiosa* and *Ralstonia solanacearum.*

15. Recommendation:

We strongly concur with the recommendation of the 1994 and 1996 reviews that two entomology positions are needed: one devoted to pests of floral crops and another for pests of woody ornamentals.

Update:

Unfortunately, the entomologist left the Unit in early 2005 and the program funds were insufficient to hire a replacement with a sustainable program. The funds were reapportioned to support related work in the pathology, tree breeding, and methyl bromide replacement programs.

16. Recommendation:

We feel that there should be two plant physiologists. One should direct attention to floral crops and the other should concentrate on the physiology of woody shrubs and trees.

Update:

Additional funding for a second plant physiologist is still highly desirable, but further funds have not yet been appropriated. A stress physiologist to complement the role of the tree and shrub breeding programs would be a valuable addition to the Unit.

Attachments:

In-Depth Review Report
Thomas Elias' Response, January 1999

Attachments for Pages 71-77:

In-Depth Review Report

Thomas Elias' Response, January 1999

These were not available for this web-based PDF version

Alignment to the ARS Strategic Plan

The Floral and Nursery Plants Research Unit is the main multidisciplinary management unit working on ornamental plants within ARS. FNPRU is unique in the degree of integration of genetic and breeding, physiology, horticulture, taxonomy, germplasm collection and preservation, and pathology across all major classes of ornamental crops. Collaborative research across individual CRIS projects addresses improvement of trees, shrubs, perennials, pot plants, cut flowers and turfgrass, through breeding, cultural modification, genetic engineering, and approaches to identify and control diseases. Research conducted within FNPRU contributes mainly to the accomplishment of ARS Strategic Plan Goal #1 (Enhance economic opportunities for agricultural producers); Goal #3 (Enhance protection and safety of the nations agriculture and food supply); and Goal #5 (Protect and enhance the nation's natural resource base and environment).

Genetics and breeding research result in new knowledge and superior cultivar and germplasm releases to the floriculture and nursery industries, one of the largest agricultural sectors in almost every state. Collection and preservation of germplasm of wild-collected plants of woody landscape plants and related species will provide genes for resistance to pests, diseases, and environmental stresses for use in internal and external breeding programs, and as a potential direct source of new introductions to the industry; the preservation and availability of wild-collected germplasm is also necessary for potential re-introduction of species for habitat restoration. Taxonomic research contributes to the success of breeding programs, ensures that scientists, nurserymen, and consumers can communicate correctly about a particular plant, and aids in identification of related plants that may have desirable (e.g. ornamental) or undesirable (e.g. invasive) characteristics. Horticulture and physiology work will aid nurserymen to produce plants with increased efficiency and reduced environmental impact. Identification and control of diseases is important to maintain or increase the quality of ornamental crops, prevent losses, and to prevent the introduction of diseases into new areas. Through integration of these disciplines, FNPRU contributes to the ARS Strategic Plan and the floriculture and nursery industries.

National Programs

Six CRIS Projects (Shrub breeding, Tree breeding, Tennessee, Taxonomy, and Biotechnology) fall under National Program 301, *Plant Genetic Resources,Genomics and Genetic Improvement*.

One CRIS Project (Floral monocots) is in National Program 302, *Plant Biological and Molecular Processes*.

The Pathology CRIS Project falls under National Program 303, *Plant Diseases*.

The Methyl Bromide Replacements CRIS Project is a part of National Program 308, *Methyl Bromide Alternatives*.

The Turfgrass CRIS project is part of National Program 205, *Rangeland, Pasture, and Forages*.

Kevin P. Conrad
Curator, Woody Landscape Plant Germplasm Repository

Research: Woody landscape plant germplasm management is very complex and requires a multi-disciplinary approach. Specifically 1) to conserve and secure a broad spectrum of woody landscape plants of diverse genetic resources of wild-origin for landscape use; 2) to establish a viable repository for the long term preservation of this germplasm in the form of seeds and clonal material 3) to transfer technology and associated information for use in research and crop improvement; and 4) to establish, manage, and make available collections information by electronic links between US National Arboretum, National Plant Germplasm System and the public sector. Wild origin germplasm will be evaluated for utilization as landscape plants, or for utilization in breeding programs, by characterizing traits of interest for propagation and ornamental value. These will involve physiological and physical changes during seed germination, vegetative growth, overwinter loss, and flowering time and duration. Accurate information on accessions will be administered and made available to the users' group.

Publications (2004-Present):

Allenstein, P. and Conrad, K.P. 2005. National Plant Germplasm System and North American Plant Collections Consortium: A Decade of Collaboration. The Public Garden 19:3 14-16, 37

Collaborators:

Ms. Pam Allenstein, NAPCC Coordinator, American Public Garden Association (APGA), and North American China Plant Collections Consortium members including :

Dr. Peter Del Tredici, Arnold Arboretum
Mr. Paul Meyer, Morris Arboretum of the University of Pennsylvania
Mr. Charles Tubesing, Holden Arboretum
Mr. Peter Wharton, University of British Columbia Botanical Garden
Mr. Kris Bachtell, Morton Arboretum
Mr Tomasz Anisko, Longwood Gardens

Mr. Rick Lewandowski, Director, Mt. Cuba Center for Piedmont Studies

Mr. Ron Lance, Curator, Chimney Rock State Park Nursery, Ashville, North Carolina

Mrs. Susan Dieter , Owner, Heartwood Nursery Inc. Mid Atlantic collection, documentation and preservation of woody landscape plant germplasm

Mr Tony Aiello, Morris Arboretum of the University of Pennsylvania, Collecting and Characterization of the genus *Hamamelis* and its related cultivars

Mr. Darrell Probst, Garden Vision Nursery, Hubbardston MA. *Epimedium* Collecting and documentation

Dr. James Chamberlain, Research Forest Products Technologist, USDA-Forest Service
Southern Research Station

Dr. Alexander Galanin, Vladivostok Botanic Garden , Vladivostok Russia

Dr. Aleksandr A. Taran, Sakhalin Botanic Garden, Sakhalin Island Russia

Donna C. Fare
Research Horticulturist

Research: The major objective of the horticulture program at the McMinnville location is to conduct studies on field and container production systems of woody ornamental crops. Current research projects include 1) identifying environmental impacts on transplant stress and plant mortality with bare root nursery stock; 2) investigating the root systems of harvested ornamental trees to determine root carbohydrate storage ability; 3) evaluating the use of water, fertilizers, and container substrate in ornamental tree production; 4) developing propagation methods for selected tree and shrub species; and 5) evaluating ornamental merit, disease and insect resistance, and stress tolerance of landscape plants.

Publications (2001 – present):

Peer-Reviewed Journal Papers:

Richardson-Calfee, L.E., J. W. Day, W. T. Witte and D.C. Fare. 2001. Effects of extended photoperiod and light quality on growth of *Carpinus caroliniana, Fagus grandifolia, and Gymnocladus dioiocus* seedlings. J. Environ. Hort. 19(4):171-174.

Dunwell, W. C., D. Fare, M.A. Arnold, K. Tilt, G. Knox, W. Witte, P. Knight, M. Pooler, W. Klingeman, A. Niemiera, J. Ruter, T. Yeager, T. Ranney, R. Beeson, J. Lindstrom, E. Bush, A. Owings and M. Schnelle. 2001. Plant evaluation program for nursery crops and landscape systems by the Southern Extension and Research Activities/Information Exchange Group-27. HortTechnology 11(3):373-375.

Altland, J.E, C.H. Gilliam, J.H. Edwards, G.J. Keever, D.C. Fare and J. L. Sibley. 2002. Eeffect of fertilizer formulation and method of application on plant growth and nitrogen leaching in urban landscapes. J. Environ. Hort. 20(4):204-213.

Altland, J.E, C.H. Gilliam, J.H. Edwards, G.J. Keever, D.C. Fare and J.L. Sibley. 2002. Rapid determination of nitrogen status in annual vinca. J. Environ. Hort. 20(3):189-194.

Lancaster, A.L., D.E. Deyton, C.E. Sams, J.C. Cummins C.D. Pless and D.C. Fare. 2002. Soybean Oil Controls Two-Spotted Spider Mites on Burning Bush. J. Environ. Hort. 20(2):86-92.

Altland, J.E., C.H. Gilliam, G.J. Keever, D.C. Fare, J. H. Edwards and J.L. Sibley. 2003. Rapid Determination of Nitrogen Status in Pansy. HortScience 38(4):537-541.

Altland, J.E, C.H. Gilliam, J.H. Edwards, G.J. Keever, D.C. Fare and J.L. Sibley. 2003. Fertilization methods affect growth, color and nitrogen leaching winter annuals in landscape beds. J. Environ. Hort. 21(2):99-107.

Pounders, C., D.C. Fare and C. Cheatham. 2004. Provenance and production location affects growth and quality of *Quercus phellos* L. and *Q. shumardii* Buckl. Seedlings. J. Environ. Hort. 22(4):202-208.

Fare, D.C., G.J. Keever and M. Halcomb. 2005. NAA reduces vegetative shoot growth on rootstocks of ornamental peach. J. Environ. Hort. 23(4):163-166.

Fare, D.C., P. Knight, C.H. Gilliam and J.E. Altland. 2005. Weed control for pot-in-pot production using preemergence herbicides. J. Environ. Hort. 23(4):204-211.

Li Yonghao, Mark Windham, Robert Trigiano, Donna C. Fare, James Spiers, and Warren Copes. 2005. Spore germination, infection structure formation and colony development of *Erysiphe pulchra* on dogwood leaves and glass slides. Plant Disease 89(12):1301-1304.

Fare, D.C. 2006. Container size and initial trunk diameter effects growth of *Acer rubrum* L. during production. J. Environ. Hort. 24(1):18-22.

Fare, D.C. Effects of container production, cupric hydroxide and production method on growth of Prunus laurocerasus L. 'Otto Lyken', 'Schipkaensis', and 'Zabeliana'. J. Environ. Hort. (submitted)

Fare, D.C. Growth of container grown trees unaffected by potting depths. HortTechnology (submitted).

Fare, D.C. Growth of container grown trees unaffected by potting depth. Arboriculture and Urban Forestry (submitted).

Li Yonghao, Mark Windham, Robert Trigiano, Donna C. Fare, James Spiers, and Warren Copes. 2005. Development of *Erysiphe pulchra*, the causal agent of powdery mildew, on susceptible and resistant flowering dogwood leaf disks. Canadian Journal of Plant Pathology. (submitted).

Other Publications:

Fare, D.C. 2001. Planting, Establishment and Pruning of Woody Ornamentals. University of Tennessee Extension Publication, Integrated Pest Management of Landscapes. University of Tennessee Publication Bulletin 1639.

Newby, A. and D.C. Fare. 2001. Maple Growth Affected by Container and Liner Size. Proc. of the SNA Res. Conf. 46:113-116. (Proceedings)

Witte W.T., M.T. Windham, A.S. Windham, F.A. Hale, D.C. Fare and W.K. Clatterbuck. 2001. Dogwoods for American Gardens. University of Tennessee Extension Publications PB1670.

Oliver, J., D.C. Fare, N. Youssef, M. Halcomb, W. Klingeman and P. Flanagan. 2002. Monitoring Buprestid Borers in Production Nursery Areas, pp. 12-13. In: G. Haun [ed.], Proceedings 29 Annual Meeting Tennessee Entomology Society, 10-11 October 2002, Nashville, Tennessee.

Moore, B., D.C. Fare, D.E. Deyton and C.E. Sams. 2003. Chemical defoliants on fall harvested bare root nursery crops. Proc. of SNA Res. Conf. 48:275-279. (Proceedings)

Oliver, J.B., D.C. Fare, N. Youssef and W. Klingeman. 2003. Collection of adult flatheaded borers using multicolored traps. Proc. of SNA Res. Conf. 48:193-199. (proceedings)

Pounders, C. and D.C. Fare. 2003. Dynamics of Oak Production from Seed. Proc. Intern. Plant Prop. Soc. 53:329-333. (Proceedings)

Robinson, D., D.C. Fare, and M. Halcomb. 2003. Weed Management in Annuals, Perennials, and Herbaceous Ground Covers. University of Tennessee Extension Publication PB 1728.

Fare, D. 2004. Effect of bare root and B&B harvest on growth and establishment of landscape size trees. Proc. of SNA Res. Conf. 53:134-136. (Proceedings)

Newby, A., J. Altland, C. Gilliam, D. Fare, and G. Wehtje. 2004. Liverwort control in container grown nursery crops. Proc. of SNA Res. Conf. 53:396-400. (Proceedings)

D.C. Fare. 2005. Fertilizer source affects nitrogen and phosphorus levels I leachate from container grown *Quercus phellos* L. and *Magnolia virginiana* L. HortScience 40(4):1048-1049. (Abstract).

D.C. Fare. 2005. Nitrogen and phosphorus levels in leachate from container-grown willow oak and sweetbay magnolia. Proc. of SNA Res. Conf. (Proceedings, submitted)

D.C. Fare. 2005. Redbud germination affected by seed treatment. Proc. of SNA Res. Conf. (Proceedings, submitted)

Li Yonghao, Mark Windham, Robert Trigiano, Donna C. Fare, James Spiers, and Warren Copes. 2005. Development of powdery mildew on resistant and susceptible dogwood cultivars. Proc. of SNA Res. Conf. (Proceedings, submitted)

Collaborators:

Dr. Joe Albano, USDA-ARS, Fort Pierce, Florida on nutritional management at container nurseries.

Dr. James Altland, Oregon State University, Aurora, Oregon on bare root tree culture.

Dr. Dennis Deyton, University of Tennessee, Knoxville, Tennessee for root carbohydrate analysis.

Dr. Charles H. Gilliam, Auburn University, Auburn, Alabama on weed control in ornamental crops.

Mr. Mark Halcomb, University of Tennessee, McMinnville, Tennessee for nursery production issues.

Dr. Gary Knox, University of Florida, Quincy, Florida for plant evaluation.

Dr. Jason Oliver, Tennessee State University, McMinnville, Tennessee on control of flatheaded borer in production nurseries.

Dr. Cecil Pounders, USDA-ARS, Poplarville, Mississippi on plant production and evaluation.

Dr. Dan Struve, Ohio State University, Columbus, Ohio for plant evaluation.

Dr. Ted Whitwell, Clemson University, Clemson, South Carolina on nutritional management at container nurseries.

Dr. Mark Windham, University of Tennessee, Knoxville, Tennessee on plant evaluation.

Dr. Tom Yeager, University of Florida, Gainesville, Florida on nutritional and water management at container nurseries.

Robert J. Griesbach
Research Geneticist

Research: A broad based research program on the genetics of floral plants is conducted. Specifically: 1) enhanced germplasm is created from wild species that expresses novel ornamental characters and is disease, insect and stress tolerant; 2) new technologies (i.e., embryo rescue, genetic engineering, molecular markers, etc.) are developed to aid in creating of novel germplasm; and 3) new technologies and methods are developed for biochemical-based flower color breeding. Research in the last five years included: 1) the creation of novel cultivars that expanded the use of a cut-flower crop to a potted-plant (*Ornithogalum*); 2) the creation of novel cultivars that expanded the use of a vegetable crop to a floral bedding plant (*Capsicum*); 3) the development of new genetic engineering technology that allows the transformation of species without the use of tissue culture; and 4) the identification and use of pH mutants in breeding *Phalaenopsis* and *Petunia* with novel flower colors. Current research involves elucidating the genetics of tissue specific anthocyanin pigmentation, including flower color patterning and leaf color. In addition, Myb and Myc anthocyanin regulatory gene vectors are developed for use in transformation to create transgenic plants with novel patterns of anthocyanin expression.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Waterworth, R. A. and Griesbach, R. J. 2001. The biochemical basis for flower color in *Calibrachoa*. HortScience 36:131-132.

Sheridan, P. M. and Griesbach, R.J. 2001. Anthocyanidins of *Sarracenia* flowers and leaves. HortScience 36:384.

Farzad, M., Griesbach, R. J. and Weiss, M. R.. 2002. Floral color change in *Viola cornuta* L. (Violaceae): a model system to study regulation of anthocyanin production. Plant Science 162:225-231.

Griesbach, R. J., Neal, J. W., and Bentz, J. 2002. Arthropod resistance in a *Petunia* ecotype with glabrous leaves. HortScience 37:383-385.

Polashock, J. L., Griesbach, R. J., Sullivan, R. F. and Vorsa, N. 2002. Cloning of a cDNA encoding the cranberry dihydroflavonol-4-reductase (DFR) and expression in transgenic tobacco. Plant Science 163:241-251.

Griesbach, R. J. 2002. Inheritance of the An2 gene and epistatic interactions in *Petunia exserta* x *P. axillaris* hybrids. J. Amer. Soc. Hort. Science 127:947-956.

Griesbach, R. J. and Santamour, Jr., F. S. 2003. Anthocyanins in cones of *Abies, Picea, Pinus, Pseudotsuga*, and *Tsuga* (Pinaceae). Biochem. System. Ecol. 31:261-268.

Griesbach, R. J. and Beck, R. M. 2003. Use of the chalcone synthase gene intron in characterizing *Petunia* taxa. Acta Hort. 623:133-138.

Gauss, J., Werner, D., Gettys, P. and Griesbach, R. J. 2003. Genetics and biochemistry of flower color in Stokes' aster. Acta Hort 624:449-453.

Farzad, M., Griesbach, R., Hammond, J., Weiss, M., and Elmendorf, H. 2003. Differential expression of three key anthocyanin biosynthetic genes in a color-changing flower, *Viola cornuta* cv. Yesterday, Today and Tomorrow. Plant Science 165:1333-1342.

Griesbach, R. J. 2004. *Hemerocallis* L. 'Chesapeake Belle'. HortScience 39:190-191.

Stommel, J. R. and Griesbach, R. J. 2004. *Capsicum annuum* L. 'Tangerine Dream'. HortScience 39:448-449.

Freyre R., and Griesbach, R. J. 2004. Inheritance of flower color in *Anagallis monelli* L. HortScience 39:1220-1223.

Griesbach, R.J. and Beck, R.M., 2005. Sequence analysis of the chalcone synthase gene in four *Petunia* taxa. J. Amer. Soc. Hort. Sci. 130:360-365.

Stommel, J.R., and Griesbach, R.J., 2005. *Capsicum annuum* L. 'Black Pearl'. HortScience 40:1571-1573.

Griesbach, R.J. and Austin, S. 2005. Comparison of the Munsell and Royal Horticultural Society's color charts in describing flower color. Taxon 54:771-773.

Other Publications:

Zimmerman, R. H. and Griesbach, R. J. 2001. Status of commercial micropropagation industry. Bull. USAMV-CN 55:19-24. (Proceedings)

Griesbach, R. J. 2002. Evolution of sexual reproduction and floral diversity. In: Breeding for Ornamentals: Classical and Molecular Approaches, ed. A. Vainstein. Kluwer Acad. Publ., Dordrecht, Germany. p.1-6. (Book Chapter)

Griesbach, R. J. 2002. Development of *Phalaenopsis* orchids for the mass-market. In: Trends in New Crops and New Uses, ed. J. Janick and A. Whipkey. ASHS Press, Alexandria, Virginia. p. 458-465. (Proceedings)

Griesbach, R. J. 2003. Orchids emerge as major world floral crop. Chronica Horticulturae 43:6-9. (Review)

Griesbach, R. J. 2004. Biochemistry and genetics of flower. Plant Breed. Rev. 25:89-114. (Review)

Griesbach, R. J. 2005. Petunia, *Petunia xhybrida*. In: Flower Breeding and Genetics: Issues, Challenges and Opportunities for the 21st Century, ed. N. Anderson. Kluwer Acad., Press, New York. (Book Chapter)

Griesbach, R.J., 2005. Biochemistry and genetics of flower color. Plant Breed. Rev. 25:89-114. (Review)

Griesbach, R.J., 2005. A scientific approach to breeding blue orchids. Orchids 74:376-379. (Trade Journal)

Griesbach, R.J., 2005. Biochemistry and genetics of flower color. Proceed. 8th Asian Pacific Orchid Conference, p.246-253. (Proceedings)

Griesbach, R.J., 2005. *Petunia x hybrida*. In: Flower Breeding and Genetics, ed. N.O. Anderson. Kluwer Press, Netherlands. p. 292-328. (Book Chapter)

Griesbach, R.J., 2005. Conservation and preservation of the genus *Phalaenopsis*. Phalaenopsis 14:14-15, 35-36. (Trade Journal)

Griesbach, R.J. and Koopowitz, H., 2005. Molecular breeding for new flower colors. Orchid Digest 69:248-253. (Trade Journal)

Patents:

Ornithogalum 'Chesapeake Starlight' US PP12,850 (8/13/02
Ornithogalum 'Chesapeake Snowflake' US PP13,200 (11/12/02)
Ornithogalum 'Chesapeake Sunset' US PP13,154 (10/29/02)
Ornithogalum 'Chesapeake Sunburst' US PP13,298 (12/03/02)
Ornithogalum 'Chesapeake Blaze' US PP13,314 (12/03/02)

Germplasm Releases:

Hemerocallis 'Chesapeake Belle' (2001)
Ornithogalum 'Chesapeake Starlight' (2003)
Ornithogalum 'Chesapeake Snowflake' (2003)
Ornithogalum 'Chesapeake Sunset' (2003)
Ornithogalum 'Chesapeake Sunburst' (2003)
Ornithogalum 'Chesapeake Blaze' (2003)
Capsicum 'Tangerine Dream' (2003)
Capsicum 'Black Pearl' (2005)

Collaborators:

Dr. John Stommel, Vegetable Laboratory, USDA-ARS-BARC, Beltsville, MD for *Caspsicum* genetics.

Dr. Rosanna Freyre, Plant Biology, University of New Hampshire, Durham, NH for *Anagallis* flower color genetics.

Dr. Wes Kloos, Genetics, North Carolina State University, Raleigh, NC for *Gerbera* flower color genetics.

Dr. Sherry Kitto, Plant and Soil Sciences, University of Delaware, Newark, DE on *Trillium* tissue culture.

Dr. Brenda Winkel-Shirley, Biology, Virginia Tech University, Blacksburg, VA on anthocyanin regulatory gene expression.

Dr. Mihal Oren-Shamir, Ornamental Horticulture, Volcani Center, Bet-Dagan, Israel on environmental control of pigmentation.

Mr. Andy Easton, Kerry's Bromeliad Nursery, Homestead, FL for *Phalaenopsis* flower color.

Ms. Donna Heaton, McCorkle Nurseries, Dearing GA for *Capsicum* and *Gaylussacia* genetics.

Mr. Phil Sheridan, Meadow View Biological Research Station, Woodford, VA on *Sarracenia* molecular markers.

Mr. Nick Pindale, Bluemount Nurseries, Monkton, MD on ornamental tissue culture.

John Hammond
Research Leader and Research Plant Pathologist

Research Leadership: Responsible for overall direction and coordination of a multidisciplinary group of 14 Category 1 and one Category 4 scientists; including tree, shrub, turf, and herbaceous plant breeding and genetics, viral, bacterial, and fungal pathology, plant physiology and transformation, taxonomy, and horticulture. The responsibilities of the laboratory include the U.S. National Arboretum Herbarium collections (over 650,000 accessions, specializing in ornamental plants and their wild relatives), and the Woody Landscape Plant Germplasm Repository (with about 3,000 living plant accessions). The Research Unit is divided between four locations (Beltsville, MD; Glenn Dale, MD; Washington, DC; and McMinnville, TN) and ten CRIS Research Projects. Familiarity with all of these projects is required to manage them,and to foster synergistic collaborations between scientists in different disciplines and different CRIS projects.

Research: Broad-based research on plant viruses is carried out under three projects. In the area of pathology, new and emerging viruses affecting ornamental plants are identified and characterized. Reagents and protocols are developed for reliable detection and identification where necessary to aid in selection or production of healthy propagation stock materials. We have recently cloned and sequenced the complete genomes of a gladiolus isolate of *Bean yellow mosaic virus*, an isolate of *Alternanthera mosaic virus* from phlox, and a novel carlavirus from phlox, as well as partial sequences of several additional potyviruses from Ornithogalum, Lachenalia, Cyrtanthus, and phlox, *Lolium latent virus* from ryegrass, a tobamovirus from Petunia, a potexvirus from Nandina, a novel carmovirus from Angelonia, an additional novel carlavirus from phlox, and novel ilarviruses from bacopa and pansy. Viral gene constructs are produced for introduction of engineered virus resistance, and we are attempting to create infectious clones of selected viruses to examine such issues as host range specificity and symptom expression. In the biotechnology and floral monocots projects, viral genes are utilized for transformation, and to examine the mechanisms of resistance to viruses in transgenic plants. Ornithogalum promoter sequences, partially synthetic promoter sequences, and transformation methods are being developed for use in transforming floral crops. The effects of virus infection on flowerbreak and anthocyanin gene regulation are also being examined.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Farzad, M., Griesbach, R.J., Hammond, J., Weiss, M., and Elmendorff, H.G. 2003. Differential expression of three key anthocyanin biosynthetic genes in a color-changing flower, *Viola cornuta* cv. Yesterday, Today and Tomorrow. Plant Science 165:1333-1342.

Hammond, J., and Hammond, R.W. 2003. The complete nucleotide sequence of isolate BYMV-GDD of *Bean yellow mosaic virus*, and comparison to other potyviruses. Archives of Virology 148: 2461-2470.

Nemchinov, L.G., Hammond, J., Jordan, R.L., and Hammond, R.W. 2004. The complete nucleotide sequence, genome organization, and specific detection of *Beet mosaic virus*. Archives of Virology 149:1201-1214.

Chen, Y.P. , Zhao, Y., Hammond, J., Hsu, H.T., Evans, J., and Feldlaufer, M. 2004. Multiple virus infections in the honey bee and genome divergence of honey bee viruses. Journal of Invertebrate Pathology 87:84-93.

Kamo, K.K., Gera, A.. Cohen, J., Hammond, J., Blowers, A., Smith, F., and van Eck, J. 2005. Transgenic Gladiolus plants transformed with either the bean yellow mosaic virus coat protein or antisense RNA. Plant Cell Reports 23:654-663.

Maroon-Lango, C., Guaragna, M.A., Jordan, R.L., Hammond, J., Bandla, M., and Marquardt, S.. 2005. Two unique US isolates of Pepino mosaic virus from a limited source of pooled tomato tissue are distinct from a third (European-like) US isolate. Archives of Virology 150:1187-1201.

Hammond, J., Reinsel, M.D., and Maroon-Lango, C.J. 2006. Identification of Potexvirus Isolates from Creeping Phlox and Trailing Portulaca as Strains of Alternanthera Mosaic Virus, and Comparison of the 3'-Terminal Portion of the Viral Genomes. Acta Horticulturae (in press).

Hammond, J., Reinsel, M.D. and Maroon-Lango, C.J. 2006. Identification and full sequence of an isolate of Alternanthera mosaic potexvirus infecting *Phlox stolonifera*. Archives of Virology 151:477-493.

Maroon-Lango, C.J., Hammond, J., Warnke, S., Li, R., and Mock, R. 2006 First report of Lolium latent virus in ryegrass in the United States. Plant Disease 90:528.

Adkins, S., Hammond, J., Gera, A., Maroon-Lango, C.J., Sobolev, I., Harness, A., Zeidan, M., and Spiegel, S. Biological and molecular characterization of a novel carmovirus isolated from Angelonia. Phytopathology (in press).

Other Publications:

Hammond, J., and Jordan, R.L. 2001. Potyviruses. Pp. 792-800 in: Encyclopedia of Plant Pathology. John Wiley & Sons, New York. (Book chapter).

Hammond, J. 2006. Current status of genetically modified ornamentals. Acta Horticulturae (in press).

Hammond, J., Hsu, H.T., Huang, Q., Jordan, R., Kamo, K., and Pooler, M. 2006. Transgenic approaches to disease resistance in ornamental crops. (invited review) Journal of Crop Improvement (in press).

Yusibov, V., Hammond, J. and Hammond, R.W. 2006. Plant Viral Vectors for Vaccine Production: Proven Value and Potential. (Book Chapter; in review).

Li, R., Maroon-Lango, C.J., Hammond, J., and Mock, R. 2006. Lolium latent virus. Molecular Diagnosis of Plant Viruses. (Book chapter, in review).

GenBank Submissions:

AY192568 Bean yellow mosaic virus, GDD isolate, complete genome
AY206394 Beet mosaic virus, complete genome
AY508411 Pepino mosaic virus, US3 strain, 3' terminal genome portion
AY509926 Pepino mosaic virus, US1 strain, complete genome
AY509927 Pepino mosaic virus, US2 strain, complete genome
AY863024 Alternanthera mosaic virus, PA (Phlox) strain, complete genome
AY850928 Alternanthera mosaic virus, BR (Phlox) strain, 3'-terminal genome portion
AY850929 Alternanthera mosaic virus, PA (Phlox) strain, 3'-terminal genome portion
AY850930 Alternanthera mosaic virus, Po (Portulaca) strain, 3'-terminal genome portion

AY850931 Alternanthera mosaic virus, SP (Phlox) strain, 3'-terminal genome portion
DQ221212 Angelonia flower break virus coat protein gene
DQ333886 Lolium latent virus, isolate UK, partial replicase sequence
DQ367732 Lolium latent virus, isolate US, partial replicase sequence
DQ355837 Ryegrass mosaic virus, 3' terminal genome portion
DQ355838 Ryegrass mosaic virus, 3' terminal genome portion

Collaborators:

Dr. John Stommel, USDA-ARS, Vegetable Laboratory, Beltsville, MD for work on *Pepino mosaic virus* and the effects of viruses on anthocyanin gene regulation.

Dr. Abed Gera, Volcani Institute, Agricultural Research Organization, Bet Dagan, Israel, for work on a carmovirus infecting Angelonia, and the effect of viruses on anthocyanin gene regulation.

Dr. Scott Adkins, USDA-ARS, U.S. Horticultural Research Laboratory, Fort Pierce, FL, for work on a carmovirus infecting Angelonia.

Dr. Vidadi Yusibov, Fraunhofer Center for Molecular Biotechnology, Newark, DE, for work on a tobamovirus infecting Petunia.

Drs. Allan Dodds and Deborah Mathews, University of California, Riverside, CA, for work on viruses infecting Verbena, Diascia, Nemesia, and Lobelia (under an SCA supported by the Floral and Nursery Research Initiative).

Dr. Melodie Putnam, Oregon State University, Corvallis, OR, for work on viruses infecting Verbena (under an SCA supported by the Floral and Nursery Research Initiative).

Drs. Dennis Lewandowski and Steven Nameth, Ohio State University, Columbus, OH, for work on a tobamovirus infecting Petunia (under an SCA supported by the Floral and Nursery Research Initiative).

Drs. Rosemarie Hammond and Lev Nemchinov, USDA-ARS, Molecular Plant Pathology Laboratory, Beltsville, MD for work on infectious clones of *Bean yellow mosaic virus* and other viruses to examine virus biology, and as potential viral vectors.

Dr. Anna Maria Vaira, Istituto do Virologia Vegetale – CNR, Torino, Italy (currently a Visiting Scientist in FNPRU) for work on an ophiovirus infecting Lachenalia, and creation of an infectious clone of Lolium latent virus.

Dr. Clarissa Maroon-Lango, USDA-APHIS-PPQ, Plant Germplasm and Quarantine Program (former post-doctoral research associate) for on-going work on Lolium latent virus, Bacopa chlorosis virus, and Ornithogalum promoters.

Dr. Mike Tiffany and others at Agdia, Inc., Elkhart, IN, for detection of viruses infecting ornamentals, and production of reagents for virus detection.

Hei-ti Hsu
Microbiologist

Research: A broad based research program that solves viral disease problems of ornamental plants. Research includes biological, immunological and molecular characterization of new or re-emerging viruses, developing efficient methods for preparation of immunogens and production of antibody reagents, improving methods for detection and identification of disease agents, and engineering resistance to viral infection. Research in the last five years includes: 1) molecularly and serologically characterized the causal agent (Calla lily chlorosis virus) that induced chlorosis in *Zantedeschia* spp. and established a new species identity in *Tospovirus*; 2) molecularly and serologically characterized Calla lily latent virus and established a new species in *Potyvirus*; 3) developed a new method of biolistic inoculation of gladiolus with *Cucumber mosaic virus* (CMV) using the Bio-Rad Gene Gun System; 4) molecularly and serologically identified two new potyviruses (Amaryllis mosaic virus and Lycoris mild mosaic virus) from diseased plants; 5) single chain (scFv) antibodies derived from CMV monoclonal antibody-secreting hybridomas were engineered and expressed in experimental plants *Nicotiana benthamiana*. Variable resistance was obtained when challenged with CMV; 6) cloned nucleocapsid (NP) protein genes from various tospoviruses into *Zucchini yellow mosaic virus* (ZYMV) expression vector and NP protein immunogens were expressed in and purified from zucchini squash, and antibodies were produced in rabbits; 7) a consensus sequence was identified in NSs genes in *Watermelon silver mottle virus* (WSMoV) serogroup of *Tospovirus*, cloned and expressed in and purified from zucchini plants. The antisera produced to the consensus sequence polypeptide react with all members of WSMoV serogroup. Current research includes: 1) characterization of a new ilarvirus infecting bacopa; 2) characterization of a new potyvirus infecting Lycoris; 3) finishing evaluation of CMV resistance in transgenic gladioli containing CP, replicase and scFv genes; 4) concluding evaluation of a consensus sequence polypeptide on NSs of *Tomato spotted wilt virus, Impatiens necrotic spot virus* and *Groundnut ringspot virus*.

Publications since 2001:

Peer Reviewed Journal Papers:

Chen, C.C., Tsao, S.L. and Hsu, H. T. 2001. Diagnosis of *Lisianthus necrosis virus* infection by light and electron microscopy and serological assays. Plant Pathol. Bull. 10:105-114.

Chen, C. C., Hu, C. C., Chen, Y. K., and Hsu, H. T. 2002. A fabavirus inducing ringspot disease in lisianthus. Acta Hort. 568:51-57.

Chang, C. A., Chen, C. C., and Hsu, H. T. 2002. Partial characterization of two potyviruses associated with golden spider lily severe mosaic disease. Acta Hort. 568:127-134.

Chen, C. C. and Hsu, H.T. 2002. Occurrence of a severe strain of *Lisianthus necrosis virus* in imported carnation seedlings in Taiwan. Plant Disease 86:444.

Chen, C.C., Ke, W.F., Lin, C.F., Jan, F.J., and Hsu, H.T. 2003. First report of *Carnation mottle virus* in calla lilies (*Zantedeschia* spp.). Plant Disease 87:1539.

Chen, C.C., Chang, C.A., Tsai, H.T., and Hsu, H.T. 2004. Isolation and identification of a newly recognized potyvirus causing latent infection on calla lilies. Plant Disease 88:1046.

Chen, C.C., Chen, T.C., Lin, Y.H., Yeh, S.D., and Hsu, H.T. 2004. Manuscript: A chlorotic spot disease on calla lilies (*Zantedeschia* spp.) is caused by a tospovirus serologically but distantly related to *Watermelon silver mottle virus*. Plant Disease 89:440-445.

Chen, Y., Zhao, Y., Hammond, J., Hsu, H.T., Evans, J., and Feldlaufer. 2004. Multiple virus infections in the honey bee and genome divergence of honey bees. J. Invert. Pathol. 87:84-93

Jan, F.Y., Chen, C.C. and Hsu, H.T. 2005. Identification of Tomato mosaic virus infection on lisianthus in Taiwan. Plant Disease 87:1537.

Aebig, J., Kamo, K., and Hsu, H.T. 2005. Biolistic inoculation of gladiolus with *Cucumber mosaic cucumovirus*. J. of Virol. Methods 123:89-94.

Chen, Y.K., Yang, C.T., and Hsu, H.T. 2005. Allamanda mosaic caused by Cucumber mosaic virus. Plant Disease 89:259.

Chen, T.C., Hsu, H.T., Jain, R.K., Huang, C.W., Lin, C.H., and Yeh, S.D. 2005. Purification and serological analysis of tospoviral nucleocapsid protein expressed by *Zucchini yellow mosaic potyvirus* vector in squash. J. Virol. Methods 129:113-124.

Lin, Y.S., Chen, T.C., Hsu, H.T., Chu, F.H., Chen, C.C., Lin, Y.Z., and Yeh, S.D. 2005. Manuscript: Serological comparison and molecular characterization for verification of Calla lily chlorotic spot virus as a new tospovirus species. Phytopathology 95:1482-1488.

Lawson, R.H., and Hsu, H.T. 2006. Quarantine viruses, viroids and phytoplasmas affecting movement of ornamental plants. Acta Hort. (in press).

Aebig, J., Albert, H.H., Zhu, B.L., Hu, J.S., and Hsu, H.T. 2006. Cloning and construction of single-chain variable fragments (scFv) to *Cucumber mosaic virus* and production of transgenic plants. Acta Hort. (in press).

Xu, M.Q., Li, H.P., Wang, M., Wu, Z.C., Borth, W.B., Hsu, H.T., and Hu, J.S. 2006. Transgenic plants expressing a single-chain Fv antibody to *Tomato spotted wilt virus* (TSWV) are resistant to TSWV systemic infection. Acat Hort. (in press).

Other Publications:

Hsu, H. T. 2001. Potato yellow dwarf *Nucleorhabdovirus*. In: "Datasheet of Quarantine Pests for Eastern Africa". FAO-CABI. (Book chapter)

Hsu, H. T. 2001. Potato yellow dwarf virus. In: "Crop Protection Compendium." CAB International.

Hsu, H. T. 2002. Biological control of plant pathogens (viruses). pp. 68-70. In: "Encyclopedia of Pest Management". Marcel Dekker, Inc., New York.

Chen, C. C. and Hsu, H. T. 2004. *Echinochloa ragged stunt virus*. In: "Virus Diseases of Poaceae (Gramineae)". Lapierre and Signoret, eds. INRA. pp. 326-330.

Hsu, H. T. and Chen, C. C. 2004. *Oryzavirus* genus. In: "Diseases of Poaceae (Gramineae)". Lapierre and Signoret, eds. INRA. pp. 757-759.

Hammond, J., Hsu, H.T., Huang, R., Jordan, R., Kamo, K., and Pooler, M. Transgenic approaches to disease resistance in ornamental crops. J. Crop Improvement (in press).

Collaborators:

Dr. Chin-An Chang, Taiwan Agricultural Research Institute, Taichung, Taiwan: Viruses infecting bulb crops.

Dr. Ching-Chung Chen, Taichung District Agriculture Improvement Station, Changhua, Taiwan: Tospoviruses and Thrips.

Dr. Yuh-Kun Chen, National Chung-Hsing University, Taichung, Taiwan: Cucumber mosaic virus (CMV) and lilies.

Dr. Abed Gera, The Volcani Center, Bet Dagan, Israel: CMV and monoclonal antibodies.

Dr. Rose Hammond, USDA-ARS, Beltsville, MD: CMV-scFv expression by Potato virus X.

Dr. Kathy Kamo, USDA-ARS, Beltsville, MD: CMV resistance in transgenic (CP, replicase, and scFv) gladiolus and lilies.

Dr. Chet Sutula, Agdia, Inc., Elkhart, IN: Virus detection technologies.

Dr. Mike Tiffany, Agdia, Inc., Elkhart, IN: Virus detection technologies.

Dr. Peter Ueng, USDA-ARS, Beltsville, MD: CMV CP gene.

Dr. Shyi-Dong Yeh, National Chung-Hsing University, Taichung, Taiwan: Tospoviruses, immunogen expression by Zucchini yellow mosaic virus.

Qi Huang
Research Plant Pathologist

Research: Dr. Huang conducts research on important bacterial diseases of floral and woody crops. Her main research interests include developing fundamental knowledge as well as tools for the detection, identification and control of bacterial pathogens affecting ornamentals; characterization of genomes and relationships of bacterial pathogens with their host(s) and the environment; and isolation of alternative promoters from double stranded DNA viruses for the development of transgenic floral crops resistant to bacterial diseases. Specific objectives of the research are: 1) conduct research on bacterial leaf scorch disease of landscape trees and shrubs caused by *Xylella fastidiosa*, including detection, genetic characterization, and relationships with hosts and vectors; 2) conduct research on the host range, epidemiology and non-pesticidal control of bacterial wilt disease of geranium caused by *Ralstonia solanacearum* race 3, biovar 2, one of the 10 plant pathogens identified by the USDA as select agents under the Agricultural Bioterrorism Protection Act of 2002; and 3) isolate an effective promoter from *Citrus yellow mosaic virus* for expression of disease resistance genes in ornamental crops and development of transgenic floral crops for disease resistance.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Huang, Q. and Hartung, J. S. 2001. Cloning and sequence analysis of an infectious clone of *Citrus yellow mosaic virus* that can infect sweet orange via *Agrobacterium*-mediated inoculation. Journal of General Virology 82: 2549-2558.

Huang, Q., Li, W. and Hartung, J. S. 2003. Association of *Xylella fastidiosa* with leaf scorch in Japanese beech bonsai. Canadian Journal of Plant Pathology 25: 401-405.

Huang, Q. and Sherald, J. L. 2004. Isolation and phylogenetic analysis of *Xylella fastidiosa* from its invasive alternative host, porcelain berry. Current Microbiology 48: 73-76.

Huang, Q. 2004. First report of *Xylella fastidiosa* associated with leaf scorch in black oak in Washington, D. C. Plant Disease 88: 224.

Huang, Q., Brlansky, R. H., Barnes, L., Li, W. and Hartung, J. S. 2004. First report of oleander leaf scorch caused by *Xylella fastidiosa* in Texas. Plant Disease 88: 1049.

Gabriel, D. W., Allen, C. A., Schell, M., Denny, T., Greenberg, J., Duan, Y. P., Flores-Cruz, Z., Huang, Q., Clifford, J. M., Presting, G., Gonzalez, E. T., Reddy, J., Elphinstone, J., Swanson, J., Yao, J., Mulholand, V., Liu, L., Farmerie, W., Patnaikuni, M., Galogh, B., Norman, D., Alvarez, A., Castillo, J., Saddler, G., Walunas, T., Zhukov, A., and Mikhailova, N. 2006. Identification of open reading frames unique to a select agent: *Ralstonia solanacearum* race 3, biovar 2. Molecular Plant-Microbe Interaction 19: 69-79.

Huang, Q., Bentz, J. and Sherald, J. L. 2006. Fast, easy and efficient DNA extraction and one-step PCR for the detection of *Xylella fastidiosa* in potential insect vectors. Journal of Plant Pathology 88: in press.

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Other Publications:

Brlansky, R. H., Howd, D. S., Huang, Q. and Hartung, J. S. 2002. Ultrastructural aspects of citrus infected with *Citrus yellow mosaic virus*, p. 378-381. *In* Proceedings of the 15th conference of the International Organization of Citrus Virologists. Edited by N. Duran-Vila, R. C. Milne and J. V. da Graca. Riverside, CA: IOCV.

J. Hammond, H.T. Hsu, Q. Huang, R. Jordan, K. Kamo, and M. Pooler. 2005. Transgenic approaches to disease resistance in ornamental crops. (invited review) Journal of Crop Improvement (in press).

GenBank Submissions:

AF347695	Full-length genome of *Citrus yellow mosaic virus*
AY196792	PCR amplification product from *X. fastidiosa* in Japanese beech bonsai
AY196793	16S-23S rRNA intergenic spacer sequence (ISS) of *X. fastidiosa*, porcelain berry strain
AY196794	16S-23S rRNA ISS of *X. fastidiosa*, mulberry strain
AY196795	16S-23S rRNA ISS of *X. fastidiosa*, wild grape strain

Collaborators:

Dr. John Hartung, Fruit Laboratory, USDA-ARS-BARC, Beltsville, MD. Detection of *X. fastidiosa* in bonsai and oleander.

Dr. Wenbin Li, Fruit Laboratory, USDA-ARS-BARC, Beltsville, MD. Detection of *X. fastidiosa* in bonsai and oleander.

Dr. James Sherald, Center for Urban Ecology, National Park Service, US Department of Interior, Washington, D.C. Isolation of *X. fastidiosa* from landscape trees and their surrounding plants, as well as detection of the bacterium in potential insect vectors.

Dr. Ronald Brlansky, Plant Pathology, University of Florida, Lake Alfred, FL. Detection of *X. fastidiosa* in oleander.

Dr. Caitilyn Allen, Plant Pathology, University of Wisconsin, Madison, WI. Biology and pathogenesis of *Ralstonia solanacearum* race 3 on geranium.

Dr. David Norman, Plant Pathology, University of Florida, Apopka, FL. Bacterial wilt host relationships.

Ramon L. Jordan
Research Plant Pathologist

Research: A broad based research program investigating the biochemical, biological, and immunological nature of ornamental plant viruses, their genomes and gene products is conducted. Develops and evaluates serological (using monoclonal antibodies) and nucleic acid-based technologies for the characterization, differentiation, and improved viral detection and identification. Develops methods to confer virus resistance through expression of single-chain antibody proteins or replicase-binding peptides in transgenic plants. Research in the last five years included: 1) determined the full-length genome sequences of four unique viruses of geranium, *Pelargonium line pattern virus*, *Pelargonium ringspot virus*, the related *Elderberry latent virus*, and *Pelargonium chlorotic ring pattern virus*; and, based on their genome organization, proposed they be included in a new genus (Pelarspovirus) in *Tombusviridae*; 2) determined the full-length genome sequences of two unique US isolates of *Pepino mosaic virus* and the 3' terminal portion of a third MD isolate; 3) discovered, partially characterized, cloned and sequenced the 3' terminal portions of seven new and emerging potyviruses infecting *Impatiens*, *Omphalodes*, *Spiranthes* orchid, *Euphorbia* 'Crown of Thorns', and *Tricyrtis* 'Toad Lily'; 4) characterized re-emerging viruses and determined new (first report) ornamental hosts for several viruses, including *Bean yellow mosaic virus* (BYMV) and *Broad bean wilt virus* (in *Verbena*), *Lily virus X* (in *Tricyrtis*), and *Dasheen mosaic virus* (in *Spiranthes*); 5) developed and evaluated the stable expression of recombinant single-chain (scFv) BYMV-specific and potyvirus broad-spectrum antiviral monoclonal antibodies (McAbs) as phage-displayed proteins in bacteria, and as TMV virus vector-expressed proteins in *N. benthamiana*; and, 6) continued collaborative research on the biological, serological and molecular characterization of, and development of detection strategies for, *Plum pox virus*. Current research includes: 1) developing full length infectious DNA clones of a Pelarspovirus to initiate gene reassortment analysis to determine virus-specific sequences responsible for disease pathology; 2) develop antiviral scFv constructs from broad-spectrum potyviral protease "HC-Pro" McAbs for expression in transgenic plants as another means of viral protection; 3) develop virus-specific and broad-spectrum reactive antibodies to viral synthetic peptides and/or bacterial expression clones for improved virus detection; 4) continue research on the detection and characterization of unknown, new and emerging viruses in important ornamental plants.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Jordan, R.L, Guaragna, M.A, Kinard, G.R., Lynn, S. 2002. Detection and first report of *Dasheen mosaic virus* and a second potyvirus infecting the terrestrial orchid *Spiranthes cernua.* *Acta Horticulturae* 568:253-260.

Jordan, R.L. and Guaragna, M.A. 2002. Successful development of monoclonal antibodies to three carnation viruses, using an admixture of only partially purified virus preparations as immunogen, and their use in virus diagnosis. *Acta Horticulturae* 568:177-184.

Kinard, G.R., Jordan, R.L. 2002. Genome organization of Pelargonium chlorotic ring pattern virus: Further implications for Tombusviridae taxonomy. *Acta Horticulturae* 568:17-27.

Gulya, T.J., Shiel, P.H., Freeman, T.F., Jordan, R.L., Isakert, T.A., and Berger, P.H. 2002. Host range and characterization of sunflower mosaic potyvirus. *Phytopathology* 92:694-702.

Nemchinov, L.G., Hammond, J., Jordan, R.L. and Hammond, R.W. 2004. The complete nucleotide sequence, genome organization, and specific detection of Beet mosaic virus. *Archives of Virology* 149:1201-1214.

Guaragna, M.A., Jordan, R.L. and Putnam, M.L. 2004. First report of *Bean yellow mosaic virus* (pea mosaic strain) in *Verbena x hybrida. Plant Disease* 88(5):574.

Maroon-Lango, C.J.M., Guaragna, M.A., Jordan, R.L., Hammond, J., Bandla, M., and Marquardt, S. 2005. Two unique US isolates of *Pepino mosaic virus* from a limited source of pooled tomato tissue are distinct from a third (European-like) US isolate. *Archives of Virology* 150:1187-1201.

Jordan, R. 2005. Development and initial characterization of monoclonal antibodies to potyviral helper-component protease. *Hybridoma* 24(2): in press.

Guaragna, M.A., Ndum, O., Jordan, R.L. 2006. Detection and characterization of two previously undescribed potyviruses in the terrestrial orchid *Spiranthes cernua*. *Acta Horticulturae*: in press.

Guaragna, M.A., Jordan, R.L., Putnam, M. 2006. First molecular evidence of the occurrence of a pea mosaic strain of *Bean yellow mosaic virus* in *Verbena* x *hybrida*. *Acta Horticulturae*: in press.

Jordan, R.L., Guaragna, M.A. 2006. Detection and characterization of a new potyvirus, Impatiens flower break virus, infecting New Guinea Impatiens. *Archives of Virology* (submitted; accepted with revision).

Other Publications:

Hammond, J. and Jordan, R.L. 2001. Potyviruses. *Encyclopedia of Plant Pathology*, pp.792-800. John Wiley & Sons, New York.

Jordan, R.L., Kinard, G. and Guaragna, M.A. 2002. Genome organization and phylogenetic relationships between members of the Tombusviridae and four distinct viruses infecting geranium. XIIth International Congress of Virology Proceedings, p442.

Jordan, R.L., and Guaragna, M.A. 2005. Detection and Molecular Characterization of New and Emerging Potyviruses of Ornamental Plants. XIIIth International Congress of Virology Proceedings, V-56, p120.

Hammond, J., Hsu, H.T., Huang, Q., Jordan, R.L., Kamo, K. and Pooler, M. 2006. Transgenic approaches to disease resistance in ornamental crops. (invited review) Journal of Crop Improvement (in press).

GenBank Submissions:

AF227728 *Pepper mottle virus*, coat protein gene
AF465545 S*unflower mosaic virus*, 3' terminal genome portion
AY038066 *Elderberry latent virus*, complete genome
AY038067 *Pelargonium line pattern virus*, complete genome
AY038068 *Pelargonium ringspot virus*, complete genome
AY038069 *Pelargonium chlorotic ring pattern virus*, complete genome
AY206394 *Beet mosaic virus*, complete genome
AY508411 *Pepino mosaic virus*, US3 strain, 3' terminal genome portion
AY509926 *Pepino mosaic virus*, US1 strain, complete genome
AY509927 *Pepino mosaic virus*, US2 strain, complete genome

AY520092 *Bean yellow mosaic virus*, PMV strain, Verbena isolate, 3' terminal portion
AY685218 *Spiranthes mosaic virus 3*, 3' terminal genome portion
AY685219 *Spiranthes mosaic virus 2*, 3' terminal genome portion
AY697300 *Euphorbia ringspot virus*, 3' terminal genome portion
AY864849 *Lily virus X*, *Tricyrtis formosana* isolate, 3' terminal genome portion
AY864850 *Tricyrtis virus Y*, 3' terminal genome portion
AY864851 *Impatiens flower break potyvirus*, 3' terminal genome portion
AY974328 *Omphalodes virus Y*, 3' terminal genome portion

CRADAs & Trusts:

Development of monoclonal antibodies to plant viruses and applications in disease diagnosis. PI on CRADA with Agdia, Inc, Elkhart, IN [1989-2002]

Development of new, superior plant virus detection methodologies and reagents. PI on CRADA with Agdia, Inc, Elkhart, IN [2005-2008].

Development of improved pathogen detection methodologies and reagents based on PCR and hybridization technologies. PI on Trust Agreement with Agdia, Inc, Elkhart, IN [2005-2007].

Collaborators:

Dr. Phil Berger, USDA-APHIS, Raleigh, NC: Potyviruses

Dr. Vern Damsteegt, USDA-ARS, Ft. Detrick, MD: Plum pox virus

Dr. Abed Gera, ARO, The Volcani Center, Israel: Ornamental plant viruses.

Dr. Graves Gillaspie, USDA-ARS, Plt Gen Res Conserv Unit, Griffin, GA: 'New' potyviruses.

Dr. Rose Hammond, MPPL, PSI, USDA-ARS, Beltsville, MD: Expression vectors, Beet mosaic virus.

Dr. Alex Karasev, Thomas Jefferson University, Philadelphia, PA: Carnation closteroviruses.

Dr. Laurene Levy, USDA-APHIS, Greenbelt, MD: Plum pox virus.

Dr. Steve Nameth, Ohio State Univ, Columbus, OH: Ornamental plant viruses.

Dr. Tom Pirone, Univ Kentucky, Louisville, KY: Potyviral HC-Pro.

Melodie Putnam, Dept Plant Pathology, Oregon State University, OR: 'New' ornamental viruses.

Dr. John Stommel, Vegetable Laboratory, PSI, USDA-ARS, Beltsville, MD: Pepper viruses.

Chet Sutula, Agdia, Inc, Elkhart, IN: Virus detection technologies, new ornamental viruses.

Mike Tiffany, Agdia, Inc, Elkhart, IN: Virus detection technologies, new ornamental viruses.

Dr. Jerry Uyemoto, USDA-ARS, Davis, CA: Prunus viruses.

Kathryn K. Kamo
Plant Physiologist

Research: The research project involves various aspects of floral crop transformation for disease resistance. This includes analysis of promoter expression, long-term expression of transgenes, and resistance conferred using antiviral transgenes. Research since the last lab review (1998) includes: 1) isolation of three ubiquitin promoters from *Gladiolus*, 2) development of a regeneration system for roses, 3) development of a transformation system for Easter lilies, 4) analysis of ten promoters in *Gladiolus* for long-term expression, and 5) transformation of *Gladiolus* for short-term resistance to bean yellow mosaic virus. Current research is developing *Gladiolus* plants with resistance to *Fusarium oxysporum* using genetic engineering and evaluating biocontrol methods, developing lily and *Gladiolus* plants with resistance to cucumber mosaic virus, optimizing a transformation system for Easter lilies for testing genes for nematode resistance, and characterization of ubiquitin promoters isolated from *Gladiolus*.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Kamo, K. 2001. Expression of the *bar* and *uidA* genes by *Gladiolus* following three seasons of dormancy. Acta Horticulturae. 560:165-167.

Joung, Y. H., Roh, M. S., Kamo, K. and Song, J. S. 2001. *Agrobacterium*-mediated transformation of *Campanula glomerata*. Plant Cell Reports. 20:289-295.

Castillon, J. and Kamo, K. 2002. Maturation and conversion of somatic embryos of three genetically diverse rose cultivars. HortScience 37:973-977.

Joung, Y. H., Liao, M. S., Roh, M. S., Kamo, K. and Song, J. S. 2002. In vitro propagation of *Campanula glomerata*, 'Acaulis' from leaf blades. Scientia Horticulturae 92:137-146.

Lipsky, A., Cohen, A., Gaba, V., Kamo, K., Gera, A., Watad, A. 2002. Transformation of *Lilium longiflorum* plants for cucumber mosaic virus resistance by particle bombardment. Acta Horticulturae 568:209-214.

Kamo, K.K. 2003. Long-term expression of the *uidA* gene in *Gladiolus* plants under control of either the ubiquitin, *rolD*, mannopine synthase, or cauliflower mosaic virus promoters following three seasons of dormancy. Plant Cell Reports 21:797-803.

Kamo, K., Jones, B., Castillon, J., Bolar, J. and Smith, F. 2004. Dispersal and filtration of embryogenic callus increases the frequency of embryo maturation and conversion for hybrid tea roses. Plant Cell Reports 22:787-792.

Kim, C.K., Chung, J.D., Park, M. Kamo, K. and Byrne, D.H. 2004. *Agrobacterium tumefaciens*-mediated transformation of *Rosa hybrida* using the green fluorescent protein (GFP) gene. Plant Cell Tisue Organ Culture 78:107-111.

Ahn, J., Joung, Y.H., and Kamo, K. 2004. Transformation of Easter lilies. Transgenic plants of Easter lily (*Lilium longiflorum*) with phosphinothricin resistance. Journal of Plant Biotechnology 6:9-13.

Kamo, K., Gera, A., Cohen, J., Hammond, J., Blowers, A., Smith, F. and Van Eck, J. 2005. Transgenic *Gladiolus* plants transformed with either the *Bean yellow mosaic virus* coat protein gene in sense or antisense orientations. Plant Cell Reports 23:654-663.

Aebig, J.A., Kamo, K. and Hsu, H.T. 2005. Biolistic inoculation of gladiolus with cucumber mosaic cucumovirus. Journal of Virological Methods 123:89-94.

Kamo, K., Jones, B., Bolar, J. and Smith, F. 2005. Regeneration from long-term embryogenic callus of the *Rosa hybrida* cultivar Kardinal. In Vitro Cellular Developmental Biology-Plant 41:32-36.

Joung, Y.H. and Kamo, K. Expression of a polyubiquitin promoter isolated from *Gladiolus.* Plant Cell Reports (accepted following minor revision)

Other Publications:

Kamo, K., Roh, M., Blowers, A., Smith, F. and Van Eck, J. Transgenic *Gladiolus*. In: Y.P.S. Bajaj (Editor) Biotechnology and Agriculture and Forestry 48. Transgenic Crops III, Springer Verlag, Berlin, pp. 155-169, 2001. (Book chapter)

Kamo, K. and Joung, Y.H. Gladiolus. In: E. Chong and M.R. Davey (Editors) Biotechnology in Agriculture and Forestry. Economic Crop Biotechnology, Springer Verlag, Berlin, 2006 (Book chapter)

Hammond, J., Hsu, H.T., Huang, Q., Jordan, R., Kamo, K., and Pooler, M. 2006. Transgenic approaches to disease resistance in ornamental crops. (invited review) Journal of Crop Improvement (in press).

Collaborators:
Drs. Lynn Carta, Andrea Skantar, and Zafar Handoo, USDA-ARS-BARC, Beltsville, MD, for biology of nematodes.

Dr. Deborah Fravel, Vegetable Laboratory, USDA-ARS-BARC, Beltsville, MD for biocontrol of *Fusarium*.

Dr.Young Hee Joung-School of Biological Science & Technology, Chonnam National University, Gwangju, Korea for *Gladiolus* promoters.

Dr. Bong Hee Han-Horticulture Research Institute, Rural Development Administration, Suwon, Korea for lily transformation.

Dr. Keerti Rathore-Crop Biotechnology Center, Texas A & M, College Station, Texas for *Fusarium* resistance by genetic engineering.

Dr. Pat Okubara, USDA ARS, Pullman, WA for *Fusarium* resistance by genetic engineering.

Dr. Jeff Cary-USDA ARS, New Orleans Southern Regional Research Center, New Orleans, LA for *Fusarium* resistance by genetic engineering.

Dr. Kanniah Rajasekaran-USDA ARS, Southern Regional Research Center, New Orleans, LA for *Fusarium* resistance by genetic engineering.

Dr. Avner Cohen-Dept. of Ornamental Horticulture, Volcani Center, Bet Dagan, Israel for horticulture of bulb crops.

Dr. Yuh-Kun Chen, Dept. Plant Pathology, National Chung Hsing University, Taiwan for CMV resistance

Mr. Lee Riddle, Easter Lily Research Foundation, Brookings, Oregon for horticulture of lilies.

Dr. Joy Bolar, Sanford Scientific, Inc., Waterloo, NY for transformation of roses.

Dr. Franzine Smith, Sanford Scientific, Inc., Waterloo, NY for transformation of roses.

Dr. David Byrne, Dept. of Horticultural Sciences, Texas A&M University, College Station, TX for transformation of roses.

Dr. Peter Ueng, USDA-ARS, Molecular Plant Pathology, Beltsville, MD for CMV in gladiolus.

Dr. Abed Gera, Volcani Center, Bet Dagan, Israel, for lily CMV.

Dr. Hei-ti Hsu, USDA-ARS, Floral & Nursery Plants Research Unit, Beltsville, MD for CMV in gladiolus and lilies.

Dr. Ramon Jordan, USDA-ARS, Floral & Nursery Plants Research Unit, Beltsville, MD for CMV in gladiolus.

Dr. Dilip Lakhsman, USDA-ARS, Floral & Nursery Plants Research Unit, Beltsville, MD for *Fusarium* challenge.

Dilip K. Lakshman
Research Plant Pathologist

Research: Conducts research on important soil-borne fungal pathogens of ornamental plants, including *Rhizoctonia solani*. Current research interests include: 1) characterization and utilization of hypovirulent isolates of *R. solani* for biological control and/or growth promotion of ornamental plants in the greenhouse; 2) characterization of fungal double-stranded RNAs (dsRNAs), fungal genes and biochemical processes affecting virulence; 3) transformation and transfection of *R. solani* with fungal dsRNAs; and 4) exploration and development of biorationals and composts as disease suppressive alternatives to methyl bromide.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Lakshman, DK, Liu, C, Mishra, PK, and Tavantzis, SM (2006). Characterization of the *arom* gene in *Rhizoctonia solani,* and transcription patterns under stable and induced hypovirulence conditions. Current Genetics 49:166-177.

Liu, C., Lakshman, D. K. and Tavantzis, S. M. 2003. Expression of a hypovirulence-causing double-stranded RNA (dsRNA) is associated with up-regulation of quinic acid pathway and down-regulation of shikimic acid pathway in *Rhizoctonia solani*. Current Genetics 42:284-291.

Liu, C., Lakshman, D. K. and Tavantzis, S. M. 2003. Quinic acid induces hypovirulence and expression of a hypovirulence-associated double-stranded RNA in *Rhizoctonia solani*. Current Genetics 43:103-111.

Invited research report:

Lakshman, DK (2006). Double-stranded RNA-mediated hypovirulence of *Rhizoctonia solani*. Association for Advancement in Plant Protection Newsletter (India). 1(1): 3.

Review:

Tavantzis, S. M., Lakshman, D. K. and Liu, C. 2001. Double-stranded RNA elements modulating virulence In *Rhizoctonia solani*. In dsRNA genetic elements – Concepts and applications in Agriculture. Forestry, and Medicine, ed. S. Tavantzis. CRC Press Tampa, Florida. p. 191-211 (Review).

Manuscripts submitted:

Meyer, S.L.F., I. A. Zasada, D.P. Roberts, B.T. Vinyard, D.K. Lakshman, J. K. Lee, D.J. Chitwood, and Carta, L.K. (2005). *Plantago lanceolata* and *Plantago rugelii* extracts are toxic to *Meloidogyne incognita* but not to beneficial plant-pathogenic microbes. Journal of Nematology (submitted).

de los Reyes, B. G., Lakshman, D. K., Yun, S. J. and Ressom, H. 2005. Agricultural Genomics. Manuscript reviewed for submission In: Agricultural Biotechnology. Eds. C. A. Georgiou and A. Nag. Prentice Hall. (Book Chapter).

Ressom, H, Lakshman, DK, Yun, SJ, Pramanik, SK and de los Reyes, BG (2006). *Microarray Data Analysis using Machine Learning Methods*. In Agricultural Biotechnology C. A. Georgiou and A. Nag eds. Printice Hall, India. (Book Chapter).

GenBank Submission:

AF482690. Complete pentafunctional *Arom* (Shikimate pathway) gene, *Rhizoctonia. solani.* (2003).

Collaborators:

Dr. Donald Nuss, University of Maryland, MD, for *R. solani* transformation and/or transfection with a cDNA clone of a double-stranded RNA.

Dr. Marc Cubeta, North Carolina State University, Raleigh, NC, for binucleate and other *R. solani* isolates.

Dr. Pat Millner, SASL, USDA-ARS, Beltsville, for with pine composting.

Dr. Jeff Buyer, SASL, USDA-ARS, Beltsville, for analysis of *R. solani* isolate and compost by chemical and biological means.

Dr. Daniel Roberts, SASL, USDA-ARS, Beltsville, for biocontrol studies.

Dr. Clifford Rice, SASL, USDA-ARS, Beltsville, for analysis of *R. solani* isolate and compost by chemical and biological means.

Dr. Amit Mitra, 406M Plant Sciences Hall, East Campus, Department of Plant Pathology
University of Nebraska-Lincoln.

Uma Shankar Singh, GB Pant University and Technology, Pantnagar 263145, U.P., India.

Dr. Samiran Gangopadhyay, Department of Plant Pathology, College of Agriculture, Rajasthan Agricultural University, Bikner-33406, Rajasthan, India

Richard T. Olsen
Research Geneticist

Research: The tree breeding program is a broad-based research effort with overall objectives of developing superior cultivars of pest-, disease-, and stress-resistant trees for landscape uses. In addition to resistance or tolerance to pests, diseases, and stresses, trees from the breeding and selection efforts will be evaluated for horticultural merit, ease of propagation, and lack of invasive characters. A new aspect of this program is the goal of breeding and selecting trees for street and utility line plantings. Efforts will continue: 1) to identify and breed hemlock (*Tsuga*) hybrids and species for resistance to the hemlock wooly adelgid; 2) to evaluate selected clones of American elm (*Ulmus Americana*) and non-American elms and hybrids for tolerance to Dutch elm disease and insects; 3) to breed and evaluate hybrid hackberry (*Celtis*) and tupelo (*Nyssa*) to select improved types; and 4) to propagate and distribute for evaluation germplasm of alder (*Alnus*), elm (*Ulmus*), hornbeam (*Carpinus*), maple (*Acer*), and zelkova (*Zelkova*) with potential for cultivar release.

Publications:

Peer-Reviewed Journal Papers:

Olsen, R. T., Ruter, J.M. , and Reiger, M.W. 2002. Photosynthetic responses of container-grown Illicium L. taxa to sun and shade. J. Amer. Soc. Hort. Sci. 127:919-924.

Dirr, M.A., Adkins, J.A. , and Olsen, R.T. 2002. Magnolia zenii Cheng. 'Pink Parchment'. HortScience 37:709-710.

Olsen, R. T., and Ruter, J.M. 2001. Preliminary study shows that cold, moist stratification increases germination of 2 native Illicium species. Native Plants Journal 2:79-83.

Other Publications:

Utilizing Polyploidy for Breeding Improved Landscape Plants. PhD thesis dissertation, North Carolina State University, 2006 (Advisor: Dr, Thomas G. Ranney)

Effects of Light Intensity and Nitrogen Nutrition on Growth and Photoinhibition of Container-grown *Illicium* L. Taxa. MS thesis dissertation, University of Georgia, 2001 (Advisor: Dr. John M. Ruter)

Collaborators:

Dr. Tom Ranney, North Carolina State University – breeding *Catalpa*, *Chilopsis*, and ×*Chitalpa*

Approximately 20 Cooperators including commercial nurseries, arboreta and botanic gardens, Forest Service, and National Park Service personnel participate in evaluation and propagation of potential cultivar releases developed by Dr. Denny Townsend.

Margaret R. Pooler
Research Geneticist

Research: The shrub breeding program is a broad-based research effort with the overall objective of developing superior cultivars of woody ornamental landscape plants that are disease and pest resistant, tolerant of environmental stresses, are not invasive, and are of superior ornamental value. This objective is accomplished by 1) Characterizing, evaluating, breeding, selecting, and releasing woody landscape plants; 2) Establishing molecular markers in specific genera, primarily *Prunus, Cercis*, and *Lagerstroemia* to aid in characterization, identification, selection and/or evaluation of plant material; 3) Using tissue culture to recover progeny from wide hybridizations and to perform chromosome manipulations, and using biotechnology to introduce new genes into cultivated germplasm of particular taxa; and 4) Coordinating cooperative programs with the nursery industry to evaluate new selections and propagate new releases, to ensure transfer of this research to the end users.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Reed, S.M., Riedel, G.L, and Pooler, M.R. 2001. Verification and establishment of *Hydrangea macrophylla* 'Kardinal' x *H. paniculata* 'Brussels Lace' interspecific hybrids. J. Environ. Hort 19(2):85-88.

Pooler, M.R. and Dix, R. 2001. Screening of *Cercis* (Redbud) taxa for ability to root from cuttings. J. Environ. Hort. 19(3):137-139.

Pooler, M.R. 2001. Plant Breeding at the U.S. National Arboretum: Selection, evaluation, and release of new cultivars. HortTechnology 11(3):365-367.

Dunwell, W.C., D. Fare, M.A. Arnold, K. Tilt, G. Knox, W. Witte, P. Knight, M. Pooler, W. Klingeman, A. Niemiera, J. Ruter, T. Yeager, T. Ranney, R. Beeson, J. Lindstrom, E. Bush, A. Owings, M. Schnelle. 2001. Plant evaluation program for nursery crops and landscape systems by the Southern Extension and Research Activities/Information Exchange Group-27. HortTechnology 11(3):373-375.

Pooler, M.R., Dix, R.L., and Feely, J. 2002. Interspecific hybridizations between the native bittersweet, *Celastrus scandens*, and the introduced invasive species, *C. orbiculatus*. Southeastern Naturalist 1(1):69-76.

Bentz, S.E., Riedel, L.G.H., Pooler, M.R. and Townsend, A.M. 2002. Hybridization and self-compatibility in controlled pollinations of eastern North American and Asian hemlock (*Tsuga*) species. J. Arboriculture 28(4): 200-205.

Pooler, M.R., Riedel, L.G.H., Bentz, S.E., and Townsend, A.M. 2002. Molecular markers used to verify interspecific hybridization between hemlock (*Tsuga*) species. J. Amer. Soc. Hort. Sci. 127(4): 623-627.

Pooler, M.R., Jacobs, K.A., and Kramer, M.H. 2002. Differential resistance to *Boyryosphaeria* canker among *Cercis* taxa. Plant Disease 86:880-882.

Pooler, M.R. 2003. Molecular genetic diversity among twelve clones of *Lagerstroemia fauriei* revealed by AFLP and RAPD markers. HortScience 38: 256-259.

Cheong, E. and Pooler, M.R. 2003. Micropropagation of Chinese redbud (*Cercis yunnanensis*) through axillary bud breaking and induction of adventitious shoots from leaf pieces. In Vitro Cell Dev Biol - Plant 39:455-458.

Elias, T.S. and Pooler, M.R. 2004. The identity of the African firebush (*Hamelia*) in the ornamental nursery trade. HortScience 39:1224-1226.

Cheong, E. and Pooler, M.R. 2004. Factors affecting somatic embryogenesis in *Prunus incisa* cv. February Pink. Plant Cell Reports 22: 810-815.

Pooler, M.R. and A.M. Townsend. 2005. DNA fingerprinting of clones and hybrids of American elm and other elm species with AFLP markers. Journal of Environmental Horticulture 23(3):113-117.

Pooler, M.R., Dix, R.L. and R.J. Griesbach. 2006. Genetic diversity of the endangered box huckleberry (*Gaylussacia brachycera*) based on AFLP markers. J. Torrey Bot. Soc. (in press)

Pooler, M.R. 2006. 'Arapaho' and 'Cheyenne' *Lagerstroemia*. HortScience (in press)

Pounders, C., Reed, S. and Pooler, M. 2006. Comparison of self- and cross-pollination on pollen tube growth, seed development, and germination in crapemyrtle. HortScience 41(3): (in press)

Ma, H., Pooler, M.R. and R.J. Griesbach. The concentration of two regulatory proteins affects the amount of anthocyanin produced in flowers. Plant Science (submitted)

Other Publications:

Pooler, M.R. 2001. Crapemyrtles. *In*: The New York/Mid-Atlantic Gardener's Book of Lists. B.L. Appleton and L.T. Chaplin (eds.). Taylor Trade Publishing, Dallas, TX. pp. 54-55. (Invited book chapter).

Pooler, M.R. and Dix, R. 2001. Evaluating *Cercis* species' ability to root from cuttings. Am. Nurseryman 194(10):56.

Bentz, S. E., L. G. H. Riedel, M. R. Pooler, and A. M. Townsend. 2002. Breeding hemlocks for resistance to hemlock woolly adelgid. p. 127-128. In: B. Onken et al., Editors. Proc. Symposium on hemlock woolly adelgid in the Eastern United States. U. S. Forest Service, Morgantown, WV. (Conference Proceedings).

Pooler, M.R. 2003. Breeding for Success. American Nurseryman 197(2): 49-50, 52.

Pooler, M.R. 2006. Crapemyrtle – *Lagerstroemia indica*. In N.O. Anderson (ed). Flower breeding and genetics: Issues, challenges, and opportunities for the 21st century. Vol. 2. p. 428-449. Springer, New York.

Hammond, J., Hsu, H., Huang, Q., Jordan, R., Kamo, K, Pooler, M. Transgenic approaches to disease resistance in ornamental crops. Journal of Crop Improvement (in press)

Germplasm Releases and Technology Transfer:

Cultivars released: *Cercis chinensis* 'Don Egolf' (2000)
Syringa 'Betsy Ross' (2000)

Prunus ‘First Lady’ (2004)
Lagerstroemia ‘Arapaho’ (2004)
Lagerstroemia ‘Cheyenne’ (2004)
Syringa ‘Old Glory’ (2006)
Syringa ‘Declaration’ (2006)

In the last four years, over 300 Materials Transfer Agreements (MTAs) have been signed between the ARS and cooperating nurseries for evaluation or stock increase of approximately 18 new plants from the Shrub Breeding Program.

Collaborators:

Dr. Tom Ranney, North Carolina State University - development of non-invasive nursery crops (SCA).

Dr. Steve Strauss, Oregon State University - development of non-invasive nursery crops (SCA).

Approximately 100 Cooperators including commercial nursery growers, arboreta and botanic garden personnel, and university and extension agents participate in the evaluation and stock increase program.

Sandra M. Reed
Research Geneticist

Research: The objective of this project is to genetically characterize and evaluate the ornamental merit, disease and insect resistance, and stress tolerance of selected nursery crop species and incorporate these traits into new or improved cultivars or breeding lines. Currently, breeding and genetics studies are being conducted in *Hydrangea*, *Clethra*, *Styrax* and *Cornus*. Both intraspecific and wide hybridization approaches are utilized with the breeding projects. Self-incompatibility, time of stigma receptivity, chromosome number, meiotic chromosome analysis, and pollen and seed storage protocols are investigated in support of the germplasm development efforts. Superior plants are selected, propagated and distributed to evaluators (nursery producers, botanical gardens and arboreta, researchers, extension specialists) for evaluation of cultivar potential. Research in the last five years included: 1) the creation, verification and application in breeding programs of interspecific and intergeneric hybrids of *Hydrangea* and *Clethra*; 2) the development of information on the pollination biology of *Hydrangea*, *Clethra*, *Cornus* and *Styrax* species; 3) the analysis of populations of *S. japonicus* for variation in time of vegetative budbreak and the selection of individuals with extended dormancy that are less likely to suffer damage from late spring freezes; and, 4) identification of a seed storage technique for *Cornus florida*. Fifteen selections were distributed to cooperators for evaluation. Current research involves expansion of wide hybridization efforts in *Hydrangea*, *Clethra* and *Cornus*, development of disease resistant *H. macrophylla* germplasm with remontant (reflowering) habit and a range of ornamental traits, development of compact *H. quercifolia* and *Clethra alnifolia* germplasm with superior floral characteristics, molecular analysis of genetic relationships within *Hydrangea*, and investigation of the genetic basis of disease resistance and ornamental traits in *H. macrophylla* and *C. florida*.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Reed, S. M., G. L. Riedel, and M. R. Pooler. 2001. Verification and establishment of *Hydrangea macrophylla* 'Kardinal' × *H. paniculata* 'Brussels Lace' interspecific hybrids. J. Environ. Hort. 19:85-88.

Reed, S. M. 2002. Flowering performance of 21 *Hydrangea macrophylla* cultivars. J. Environ. Hort. 20:155-160.

Reed, S.M., Y. Joung, and M.S. Roh. 2002. Interspecific hybridization in *Clethra*. HortScience 37:393-397.

Reed, S. M. 2003. Self-fertility and time of stigma receptivity in *Styrax japonicum*. HortScience. 38:429-431.

Reed, S. M. 2004. Self-incompatibility and time of stigma receptivity in two species of *Hydrangea*. HortScience. 39:312-315.

Reed, S. M. 2004. Self-incompatibility in *Cornus florida*. HortScience. 39:335-338.

Reed, S. M. 2005. Effect of storage temperature and seed moisture on germination of stored flowering dogwood seed. J. Environ. Hort. 23:29-32.

Reed, S. M. 2005. Pollination biology of *Hydrangea macrophylla*. HortScience 40:335-338.

Reed, S. M. 2005. Cytological analysis of a *Clethra alnifolia* 'Hokie Pink' × *C. pringlei* hybrid. HortScience 40:339-342.

Reed, S. M. 2005. Japanese snowbell exhibits variability for time of vegetative budbreak and susceptibility to spring freeze damage. HortScience 40:542-545.

Jones, K.D. and S.M. Reed. 2006. Production and verification of *Hydrangea arborescens* 'Dardom' × *H. involucrata* hybrids. HortScience (in press).

Pounders, C., S. M. Reed and M.R. Pooler. 2006. Comparison of self- and outcrossing on pollen tube growth, seed development and germination in crapemyrtle. HortScience (in press).

Reed, S.M. 2006. Reproductive biology of *Clethra alnifolia*. HortScience (in press).

Other Publications:

Reed, S.M. 2001. Hybridization of *Clethra alnifolia* and *C. pringlei*. Proc. Southern Nursery Assoc. Res. Conf. 46:407-410. (Proceedings)

Reed, S.M. 2001. Hydrangeas for the future. Proc. Intl. Plant Prop. Soc. 51:457-461. (Proceedings)

Reed, S.M. 2003. Self-incompatibility in *Hydrangea paniculata* and *H. quercifolia*. Proc. Southern Nursery Assoc. Res. Conf. 48: 477-479. (Proceedings)

Reed, S.M. 2004. Floral characteristics of a *Hydrangea macrophylla* × *H. paniculata* hybrid. Proc. Southern Nursery Assoc. Res. Conf. 29:580-582. (Proceedings)

Jones, K.D. and S.M. Reed. 2005. Recent developments in *Hydrangea* interspecific hybridization. Proc. Southern Nursery Assoc. Res. Conf. (in press). (Proceedings)

Reed, S.M. 2005. Haploid cultures. In: Plant Development and Biotechnology (ed. R.N. Trigiano and D.J. Gray). CRC Press, Boca Raton. pp. 225-234. (Book Chapter)

Reed, S.M. 2005. Embryo rescue. In: Plant Development and Biotechnology (ed. R.N. Trigiano and D.J. Gray). CRC Press, Boca Raton. pp. 235-239. (Book Chapter)

Reed, S.M. 2005. Stabilizing dogwood seed supply through proper storage of excess seed. Proc. Southern Nursery Assoc. Res. Conf. (in press). (Proceedings)

Rinehart, T.A., Scheffler, B. and S.M. Reed. 2005. Estimating genetic diversity within the *Hydrangea* genus using molecular markers. Proc. Southern Nursery Assoc. Res. Conf. (in press). (Proceedings)

Collaborators:

Dr. Margaret Mmbaga, Tennessee State University Nursery Research Center, McMinnville, Tenn. for *Cornus* breeding and disease resistance in *Hydrangea*.

Dr. Tim Rinehart, USDA-ARS, Poplarville, Miss. for *Hydrangea* genetics.

Dr. Robert Trigiano, University of Tennessee, Knoxville, Tenn. for disease resistance in *Hydrangea.*

Dr. Mark Windham, University of Tennessee, Knoxville, Tenn. for disease resistance in *Hydrangea.*

Dr. Cecil Pounders, USDA-ARS, Poplarville, Miss. for *Lagerstroemia* pollination biology.

Approximately 50 cooperators (nursery producers, researchers, extension specialists, arboreta and botanical gardens) involved in evaluation of selections for cultivar release.

Mark S. Roh
Research Horticulturist
Woody Landscape Plant Germplasm Repository

Research: This project addresses ARS National Program 301, "Plant, Microbial, and Insect Genetic Resources, Genomics and Genetic Improvement", Component I, "Genetic Resources Management". The overall objectives of this project statement on woody landscape plant germplasm repository (WLPGR) are to conserve a broad spectrum of woody landscape plant genetic resources and associated information for use in research and crop improvement. Specific goals for research component are: 1) to improve seed germination in short period of time by investigating the effect of *Styrax* seed maturity, warm and cold stratification treatment; 2) to investigate the metabolism in association with overwinter loss of young propagules of *Styrax* and with heat stress in *Abies* and *Pinus*; 3) to select and evaluate germplasm, such as *Halesia*, and *Deutzia* for horticultural merits; and 4) to characterize, identify, and study genetic diversity of *Pinus koraiensis*, *Ilex* x *wandoensis*, and *Halesia tetraptera* using molecular markers. Research utilizing molecular markers, scanning electron microscopy, and nuclear magnetic resonance imaging techniques in the last five years included: 1) *In vitro* propagation from leaf blade explants, forcing, and molecular characterization, and *Agrobacterium*-mediated transformation *Campanula*; 2) identification and classification of the Genus *Lycoris*, of interspecific hybrids of *Clethra*, genetic relationships of *Ardisia*, paternity test of *Ornithogalum* hybrids, and diversity of *Dendranthema*; 3) maturity and temperature stratification on the germination of *Styrax japonicus* seeds; 4) inflorescence development in an *Ornithogalum dubium* hybrid and of *Lachenalia* as influenced by bulb temperature treatment.

Publications (2001 – present):

Peer-Reviewed Journal Papers:

Joung, Y. H., Roh, M. S., Kim, T. I., and Song, J. S. Forcing and molecular characterization of *Campanula*. Acta Hort. 546:421-425. 2001.

Joung, Y. H., Roh, M. S., and Bentz, S. E. Characterization of *Acer griseum* and its putative interspecific hybrids. Acta Hort. 546:217-220. 2001.

Lee, J. S., and Roh, M.S. Influence of frozen storage duration and forcing temperature on flowering of Oriental hybrid lilies. HortScience 36:1053-1056. 2001

Joung, Y. H., Roh, M. S., Kamo, K., and Song, J. S. *Agrobacterium*-mediated transformation of *Campanula glomerata*. Plant Cell Rep. 20:289-295. 2001.

Song, J. S., Roh, M. S., and Suh, J. K. New floral crops of the world and the prospect of Korean wild flowers. Kor. J. Hort. Sci. & Tech. 19:253-251. 2002.

Joung, Y. H., Liao, M. S., Roh, M. S., Kamo, K., and Song, J. S. *In vitro* propagation of *Campanula glomerata*, 'Acaulis' from leaf blade explants. Scientia Hort. 92:147-146. 2002.

Reed, S. M., Joung, Y., and Roh, M. Interspecific hybridization in *Clethra*. HortScience 37:393-397. 2002.

Roh, M. S., Kurita, K., Zhao, X. Y., and Suh, J. K. Identification and classification of the Genus *Lycoris* using molecular markers. J. Kor. Soc. Hort. Sci. 43:120-132. 2002.

Lee, A-K, Suh, J-K., Roh, M. S., and Slovin, J. P. Analysis of genetic relationships of *Ardisia* spp. Using RAPD markers. J. Hort. Sci. & Biotech. 78 (1): 24-28. 2003.

Roh, M. S. and Ikeda, H.. Genetic diversity of *Dendranthema pacificum* (Nakai) Kitam native to Japan. Acta Hort. 630: 239-244. 2003.

Roh, M. S. and Bentz, J.-A. Germination of *Styrax japonicus* seeds as influenced by storage and sowing condition. Acta. Hort. 630: 411-416. 2003.

Joung, Y. H. and Roh, M. S. Paternity determination of *Ornithogalum* seedlings using DNA markers. J. Hort. Sci. & Biotech. 79 (2): 316-321. 2004.

Roh, M. S. and Joung, Y. H. Inflorescence development in an *Ornithogalum dubium* hybrid as influenced by bulb temperature treatment. J. Hort. Sci. & Biotech. 79 (4): 576-581. 2004.

Roh, M. S., Bentz, J-A., Wang, P., Li, E., and Koshioka, M. Maturity and temperature stratification affect the germination of *Styrax japonicus* seeds. J. Hort. Sci. & Biotech. 79 (4): 645-651. 2004.

Song, C.Y., Lee, N. S., and Roh, M. S. 2004. Morphological characters and molecular markers for selection of *Campanula portenschlagiana* hybrids *Song, C.Y., Lee, N. S.,* and Roh, M. S. J. of Kor. Soc. For Hort. Sci. 45:261-269.

Roh, M. S., L*ee, A-K,* and Suh, J-K. 2005. Production of high quality *Ardisia* plants by vegetative propagation. Scientia Hort. 104:292-303.

Roh, M. S. 2004. Flowering and inflorescence development of *Lachenalia aloides* 'Pearsonii' as influenced by bulb storage and forcing temperature. Scientia Hort. 104:305-323.

Meerow, A. W., Roh, M. S., Schnell, R. J. 2005. Sixteen microsatellite loci from *Halesia tetraptera* (Styracaceae). Molecular Biology Notes. 5:777-779.

Joung, Y. H., and Roh, M. S. 2005. Mapping characterization of *Pinus sylvestris* var. *sylvestriformis* based on chloroplast DNA microsatellite markers. Forest Genetics 12:89-98.

Collaborators:

Dr. Alan Meerow – USDA, ARS, National Germplasm Repository, Miami, Florida for characterization of *Halesia*

Dr. William McNamara – Quarryhill Botanical Garden, Glen Ellen, California for population study of *Acer pentapetallum*

Dr. Cliff Parks – University of North Carolina for cold hardiness of *Camellia*

Dr. Christina Walters – USDA, ARS, National Center for Genetic Resource Preservation, Fort Collins, Colorado for lipid analysis of *Styrax* and/or *Pinus*

Dr. Erching Li – Dept. of Chemistry, Georgetown University for MRI on *Styrax* and *Pinus*

Dr. Janet Slovin – USDA, ARS, PSI, Fruit Laboratory, Beltsville, MD for seed germination and characterization of *Ardisia*

Dr. Jeannine Rowland – USDA, ARS, PSI, Fruit Laboratory, Beltsville, MD for cold hardiness of *Camellia*

Dr. Jeung-Keun Suh – Faculty of Bio-Sciences, Dankook University, Korea for germplasm collection and *Ardisia* project

Dr, Masaji Koshioka – Dept. of Genetics and Plant Physiology, National Institute of Floricultural Science, National Agricultural Research Organization, Japan for gibberellin analysis and MRI on *Pinus*

Mr. Ding Mu – Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, China for germplasm exchange of *Pinus*

Dr. Nam Sook Lee - Department of Life Sciences, Ewha Womans University, Korea for germplasm collection and characterization of *Ilex* and *Corylopsis*

Dr. Paul Wang – Medical School, Howard University for MRI on Pinus *Stryax* and *Ardisia*

Dr. Takayuki Kawahara – Forestry and Forest Products Research Institute (FFPRI) Forest, Diversity and Dinamics Group, Japan for germplasm collection of *Pinus*

Dr. Tomasz Anisko – Longwood Gardens, Kenneth Square, PA for cold hardiness of *Camellia*

Dr. Young Hee Joung – School of Biological Science & Technology, Cheonnam National University, Korea for characterization on *Pinus* and *Ornithogalum*

Scott E. Warnke
Research Geneticist

Research: A research program on the genetics of plants used as turfgrasses is conducted. Specifically: 1) enhanced germplasm is created from wild species that expresses improved biotic and abiotic stress resistance; 2) new technologies (i.e., embryo rescue, molecular markers, genomics, etc.) are developed to aid in creating novel germplasm; 3) new technologies and methods are developed for isolating turfgrass germplasm with enhanced biotic and abiotic stress resistance. Research in the last three years included: 1) the generation of AFLP markers in creeping bentgrass (*Agrostis stolonifiera*) to evaluate chromosome pairing behavior ; 2) Expressed Sequence Tag sequencing of creeping and colonial bentgrass cDNA libraries and the isolation of EST SSR markers for genetic map development and genetic diversity evaluation; 3) Evaluation of tall fescue (Festuca arundinaceae) EST SSR markers for genetic diversity assessment. 4) The evaluation of transposable elements in creeping and colonial bentgrass for genetic mapping and species seperation.

Publications (2001-Present):

Peer-Reviewed Journal Papers:

Barker, R.E., J.A. Kilgore, R.L. Cook, A.E. Garay, and S.E. Warnke, 2001. Use of flow cytometry to determine ploidy level of ryegrass. Seed Sci. & Technol., 29:493-502.

Warnke S.E., R.E. Barker, L.A. Brilman, W.C. Young III, and R.L. Cook. 2002. Inheritance of superoxide dismutase (Sod-1) in a perennial X annual ryegrass cross and its allelic distribution among cultivars. Theor Appl Genet 105:1146-1150.

Warnke, S.E., R.E. Barker, Geunhwa Jung, Sung-Chur Sim, M.A. Rouf Mian, M.C. Saha, L.A. Brilman, M.P. Dupal, J.W. Forster. 2004. Genetic linkage mapping of an annual X perennial ryegrass population. Theor Appl. Genet. 109:294-304

Sim S., Chang T., Curley J., Warnke S.E., Barker R.E., Jung G. 2005 RFLP Marker Based Analysis of Large-Scale Chromosomal Rearrangements Differentiating the Lolium Genome From Other Poaceae Species Theor Appl Genet. 110:1011-1019.

Curley, J., Sim, S.C**.,** Warnke, S.E., Leong, S.A., Barker, R.E., Jung, G. 2005. Genetic variability and QTL mapping of resistance to gray leaf spot in ryegrass. Theor Appl. Genet. 111:1107-1117.

Chakraborty, N, Bae, J, Warnke, S, Chang, T and Jung, G. 2005. Linkage map construction in allotetraploid creeping bentgrass (*Agrostis stolonifera* L.) Theor. Appl. Genet. 111:795-803.

Barker R.E., Warnke S.E., and Brown R.N.2005 Genetic Variability Among Intermediate Ryegrass Seed Lots and Cultivars Detected by RAPD. Analysis.International Turfgrass Society Research Journal. 10:490-494.

Brown R.N., Barker R.E., Warnke S.E., Brilman L.A., Mian Rouf M.A., Jung G., and Sim S. 2005. QTL Analysis for Morphological Traits Useful in Distinguishing Annual Ryegrass and Turf-type Perennial Ryegrass. International Turfgrass Society Research Journal. 10:515-524

Other Publications:

Warnke S.E. 2003. Creeping bentgrass. p.175-185 In M.D. Casler and R.R. Duncan (ed.) Turfgrass Biology, Genetics, and Breeding. John Wiley & Sons, Inc. Hoboken, New Jersey. USA.

Curley J., Sim S.C., Jung G., Leong S., Warnke S.E., Barker R.E 2004 QTL mapping of Gray leaf spot resistance in ryegrass, and synteny-based comparison with rice blast resistance genes in rice. Molecular Breeding of Forage and Turf Conference Proceedings, Kluwer Academic Publishers, Boston USA

Collaborators:

Dr. Reed E. Barker, National Forage Seed Production Research Center, USDA-ARS, Corvallis, OR for *Lolium* genetic mapping and species separation.

Dr. Geunhwa Jung, Department of Plant Pathology, University of Wisconsin, Madison, WI for *Agrostis* genetic mapping and disease resistance evaluation.

Dr. Stacy Bonos, Rutgers University, New Brunswick, NJ for *Agrostis* genetic mapping and disease resistance evaluation

Dr. Faith Belanger, Rutgers University, New Brunswick, NJ for Agrostis EST evaluation and genetic map development.

Dr. Suleiman Bughrara, Michigan State University, East Lansing, MI, for the development of ryegrass fescue species hybrids with improved stress resistance

Dr. Shui Zang Fei, Iowa State University, for evaluation of cold hardiness in ryegrass

Dr. Malay Saha, Noble Foundation, Ardmore, OK, for the evaluation of tall fescue EST SSR markers

Dr. Rebecca N. Brown, University of Rhode Island, *Lolium* genetic mapping and species separation

Dr. Brandon Horvath, Virginia Tech University, Evaluation of tall fescue germplasm for Rhizoctonia patch resistance.

Alan T. Whittemore
Research Taxonomist

Research: A broad based program of research on the taxonomy of woody plants and curation of the National Arboretum herbarium is conducted. Work focuses on: 1) assessment of systematic relationships and the amount and apportionment of genetic diversity within and between species are, focusing on *Celtis* and *Quercus*, developing genetic marker systems that will facilitate this work and at the same time be useful for breeding and selection work in these genera; 2) management and development of the National Arboretum herbarium, the only large herbarium in USDA, focusing on cultivated/domesticated plants; 3) collaboration in the documentation of emerging invasive woody plants, and the investigation of traits contributing to their invasiveness; and 4) determination of the valid botanical and cultivar names for landscape trees and shrubs, and to ensure that those names are properly and consistently applied. Research in the last four years included: 1) demonstrating that species of *Celtis* subgenus *Celtis* hybridize much less readily and much less frequently than had been supposed, and that patterns of variation previously attributed to frequencies of hybridization are actually due to developmental variability and apomixis; and 2) revising several plant families for floristic, manuals, gathering data from recent collections and integrating conclusions from recent literature to update the taxonomy of these groups. Current research involves elucidating the relationships and crossability of *Celtis* subgenus *Celtis*, marker distribution in *Quercus*, further development of the National Arboretum herbarium collection, and the changing flora of the National Arboretum grounds.

Publications (2002-Present):

Peer-Reviewed Journal Papers:

Whittemore, A. T. 2003. Noteworthy collections (District of Columbia). Castanea 68: 261.

Whittemore, A. T. 2004. Sawtooth oak (*Quercus acutissima*, Fagaceae) in North America. Sida 21: 447-454.

Whittemore, A. T. 2005. Introgression, genetic structure, and taxonomic status in the *Celtis laevigata* - *C. reticulata* complex (Cannabaceae). Systematic Botany 30: 809-817.

Whittemore, A. T. 2005. Validation of the Name *Ilex* X *aquipernyi* J. B. Gable (Aquifoliaceae). Novon 15: 493-494.

Whittemore, A. T. and K. C. Nixon. 2005. Proposal to reject the name *Quercus prinus* L. (Fagaceae). Taxon 54: 213-214.

A. T. Whittemore. 2006. Notes on Southwestern Moraceae. Sida: Contributions to Botany 22(1): in press.

A. T. Whittemore and A. H. Townsend. Hybridization and Self-Compatibility in *Celtis*: AFLP Analysis of Controlled Crosses. Journal of the American Society of Horticultural Science: Accepted pending revision.

Peer-Reviewed Book Chapters:

Whittemore, A. T. and A. E. Schuyler. 2003. *Scirpus*. Flora of North America volume 23. Oxford University Press. Pp. 8-21.

Reznicek, A. A., J. E. Fairey III and A. T. Whittemore. 2003. *Scleria*. Flora of North America volume 23. Oxford University Press. Pp. 242-251.

Fu L.-G, Xin Y.-Q., and A. T. Whittemore. 2004. Ulmaceae. Flora of China, volume 5. Missouri Botanical Garden Press, St. Louis. Pp. 1-9.

Whittemore, A. T. In press. Betulaceae. Flora of Missouri, volume 2. Missouri Department of Conservation, Jefferson City.

Whittemore, A. T. In press. Caprifoliaceae. Flora of Missouri, volume 2. Missouri Department of Conservation, Jefferson City.

Whittemore, A. T. In press. Moraceae. Flora of Missouri, volume 3. Missouri Department of Conservation, Jefferson City.

Whittemore, A. T. In press. Juglandaceae. Flora of Missouri, volume 3. Missouri Department of Conservation, Jefferson City.

Whittemore, A. T. In press. Caprifoliaceae. Flora of Missouri, volume 3. Missouri Department of Conservation, Jefferson City.

Whittemore, A. T. In press. Juglandaceae. The Jepson Manual: Higher Plants of California ed. 2. University of California Press, Berkeley.

Whittemore, A. T. In press. Zingiberaceae. The Jepson Manual: Higher Plants of California ed. 2. University of California Press, Berkeley.

Other Publications:

2002. A. T. Whittemore. 2002. Obituary of: Joseph Andorfer Ewan (1909 - 1999) and Ada Nesta Ewan (1908 - 2000). Bartonia 61: 137-142.

Collaborators:

Dr. Victoria Sork, University of California, Los Angeles, for *Quercus* population genetics.

Dr. David Tay, USDA Ornamental Plant Germplasm Center, Columbus OH, on plant exploration, herbarium documentation of USDA collections, and taxonomic support on ornamental plants.

Dr. Art Tucker, Delaware State University, for herbarium development and (I am USDA collaborator on his 1890 capacity improvement grant).

Support Staff, Post-doctoral, and Visiting Scientists

Support Staff

Tom **Abell**
Gardener [note: in May of 2005 this position was transferred to Research Support Services]
Maintains field plots, and greenhouse in support of tree research. Plants, pots, propagates and waters research plant materials. Maintains, operates and transports equipment for tree plantings.

Keenan **Amundsen**
Plant Biology Research Technician
Contributes to the research program designed to enhance/identify biotic and abiotic stress resistant turfgrass germplasm. Maintains turfgrass germplasm and investigates the use of DNA marker techniques to map and identify interesting varieties.

Kathryn **Baker**
Support Services Assistant
Responsible for the administrative management of the Floral & Nursery Plants Research Unit Lab office. Performs administrative duties related to budget, procurement, travel, personnel, research documentation (ARIS), records and office support services. Kate serves as the USNA Institute contact for ARIS advice and procedures.

Ronald M. **Beck**
Horticulturist
Supports research on the molecular biology of anthocyanin regulatory genes and conducts research on the genetic analysis of Petunia x hybrida anthocyanin gene expression. Clones and sequences regulatory gene segments containing introns. Helps produce transgenic plants and maintains germplasm in vitro and in the greenhouse.

Susan **Bentz**
Horticulturist
Hybridizes and evaluates hemlock species for resistance to woolly adelgid. Develops techniques for propagating superior selections of disease and insect-resistant trees. Manages national tree distribution and evaluation program. Co-produces plant Fact Sheets.

Michael **Chamberland**
Botanist
Maintains the collections of the U.S. National Arboretum Herbarium, and supports research related to the taxonomy of woody landscape plants. Collects, prepares, mounts and documents specimens for addition to the Herbarium collections; loans and exchanges specimens with other herbaria. Identifies plants and provides other taxonomic expertise for the public.

Margaret **Dienelt**
Plant Pathologist
Manages electron microscopy laboratory. Provides transmission and scanning electron microscopy in support of laboratory research, primarily for pathology-related projects. Determines host cytological responses to virus infection and assists in identifying unknown plant viruses.

William Edgar **Davis**
Agricultural Science Research Laboratory Technician
Responsible for plant maintenance including plot preparation, planting, potting, fertility, pest control, irrigation and pruning for research projects in the horticulture and plant breeding labs at the McMinnville worksite. Maintains propagation material and assists with plant propagation and hybridization. Assists with data collection and maintains historical information on field and container plots. Maintains, calibrates, and operates field nursery equipment. Responsible for the pest control program including scouting and utilizing IPM techniques to either prevent or control pest problems.

Sue **Greeley**
Agricultural Science Research Technician (plants)
Supports shrub breeding unit by serving as field manager for 40+ acres of research plant material in DC and WV. As an arborist for the USNA, oversees tree contract, answers tree concerns and ensures that employees and contractors follow appropriate arboricultural principles and practices. Applies IPM principles as part of plant health practices. Serves as wildlife manager and expert for USNA-DC campus.

Mary Ann **Guaragna**
Plant Pathologist
Supports research on investigations on the biochemical and serological nature of plant viruses, their genomes and gene products, including new and emerging viruses in ornamentals. Coordinates and performs recombinant DNA-related experiments, including the expression of viral or anti-viral genes in transgenic plants. Maintains, operates, and coordinates use of laboratory DNA sequencer and genetic analyzer instrument.

Charity **James**
Microbiologist
Supports research on plant viral diseases, determining host range, performing virus purifications, serological assays, PCR, for virus identification and characterization. Maintains transgenic plants in tissue culture and performs biolistic inoculation to challenge transgenic plants expressing viral genes or anti-viral antibodies.

David **Kidwell-Slak**
Horticulturist (Support Scientist) [effective April, 2006]
Provides support to the shrub breeding unit by conducting and/or supervising the propagation, evaluation, and distribution of genetically improved shrubs. Responsible for the maintenance and daily plant care activities of the greenhouse/polyhouse/lathhouse area. Conducts research on propagation, performance, or genetics of selected genera. Performs pollinations, maintains breeding, accession, propagation, and distribution records for shrub breeding program.

Frances **Kolpack**
Office Management Assistant
Serves as Office Management Assistant to the Support Services Assistant, Research Leader (RL) and staff of the Floral and Nursery Plants Research Unit (FNPRU), U.S. National Arboretum, Beltsville, MD. Responsible for a broad range of administrative support functions in support of the Research Unit.

Hongmei **Ma**
Geneticist
Dr. Ma supports the shrub breeding unit by investigating the genetic relationship of flowering cherries using molecular markers (SSR). Establishes transient gene expression system to evaluate expression of

promoters and reporter genes in various constructs. Studies the genetic regulation of anthocyanin biosynthesis for possible development of new foliage pigmentation in woody plants.

Ramona A. **Mathis**
Office Automation Clerk
Provides clerical, administrative, and program support to USDA/ARS personnel located at the McMinnville worksite. Also handles personnel actions, communications, procurement, and general office duties.

John **McKenzie**
Agricultural Science Research Technician (Plants)
Supports the research activities of FNPRU scientists through propagation and maintenance of experimental plants. Monitors and regulates greenhouses and growth chambers used by FNPRU researchers at BARC via multiple greenhouse computers. Orders greenhouse supplies for various research projects.

Anne Siobhan **O'Connor**
Biological Lab Technician (Microbiology)
Assists in research on expression of transgenes at the protein and RNA level. Identifies integration of transgenes into genomic DNA of transgenic plants. Maintains plant cell lines in tissue culture and the greenhouse.

Suzanne **Overbey**
Biological Science Technician (Plants)
Supports plant breeding and genetics program at the McMinnville worksite by hybridizing plants, collecting and germinating seed, and growing plants to maturity. Tissue culture embryo rescue techniques are used as needed. Maintains health of container-grown plants and keeps laboratory and greenhouse equipment in working condition.

Michael **Reinsel**
Biological Laboratory Technician (Microbiology)
Supports research in plant virology, investigating biochemical and serological nature of plant viruses, their genomes and gene products. Performs virus purifications, host range studies, serological assays, cloning and sequencing for virus identification and characterization. Assists with tissue culture and plant transformation studies. Maintains and operates a genetic analyzer for sequencing and DNA marker studies to support multiple laboratories.

Jeffrey **Rex**
Biological Science Lab Technician (Microbiology)
Supports research on important bacterial diseases of floral and woody crops. Responsible for bacterial isolation from plant samples, maintenance of bacterial cultures, propagation and maintenance of greenhouse plants. Prepares DNA from plants, bacteria and insects, and performs PCR and ELISA.

Louise **Riedel**
Botanist
Supports research related to the taxonomy of woody landscape plants, primarily through the analysis of DNA and other markers from woody plant tissues. Performs experiments identifying markers and sequences to verify taxonomic relationships or hybridity. Maintains, operates, and co-ordinates use of DNA sequence and fragment analyzer.

Martin **Scanlon**
Agricultural Science Research Technician
Supports the operations of the Woody Landscape Plant Germplasm Repository. Maintains the living plant collections, collects seed, propagates plants for planting and distribution, and participates in national and international germplasm collections trips.

Sue Sue **Scholl**
Biological Science Research Laboratory Technician
Manages research projects in the horticulture lab at the McMinnville worksite and oversees data collection and scheduling. Determines and utilizes best laboratory procedures for plant and leachate nutrient analysis. Maintains, calibrates, and operates equipment, including the LICOR 6400 photosynthesis system and the Dynamax Flow32sap flow system. Statistically analyzes and summarizes data using SAS v9.0.

[**Vacant**]
Biological Science Lab Technician [Plants]
Supports research on genetic diversity and other topics related to the maintenance and propagation of woody landscape germplasm. Coordinates experiments intended to obtain novel genetic markers for valuable commercial traits. Maintains, operates, and coordinates use of laboratory HPLC.

[**Vacant**]
Biological Science Laboratory Technician (Insects)
Supports research on insect pests of woody ornamentals related to the tree and shrub breeding programs. Responsible for the growing of plant material, maintenance of insect colonies, set-up of experiments and data collection. Initiates and implements pest control strategies as needed in assigned greenhouse space.

Perry **Wilcox**
Gardener [note: in May of 2005 this position was transferred to Research Support Services]
Supports shrub breeding unit by providing daily plant care of container material in greenhouses and polyhouses, as well as maintenance of material in lath-house area and mowing all research nurseries. Duties include watering, potting, soil mixing, fertilizing, mowing, mulching, plant removal and clean-up, weeding, and daily reporting of greenhouse conditions.

Post-doctoral Scientists

Clarissa J. **Maroon-Lango**
Research Molecular Biologist (Plants) [January 2002 - January 2006]
Dr. Maroon-Lango performed characterization of actin promoters from Ornithogalum species and analysis of promoter activities in homologous and heterologous plant-derived systems; detection, identification and characterization of plant viruses; and developed molecular tools for the detection of plant viruses.

Keri **Jones**
Research Geneticist (Plants)
Dr. Jones supports the plant breeding program at the McMinnville worksite by conducting wide hybridization studies in *Hydrangea* and *Cornus*. Uses embryo rescue as needed to secure hybrids. Verifies and characterizes hybrids with molecular and cytological techniques.

[**Vacant**]
Post-doctoral Research Associate, Plant Pathologist/Molecular Biologist
An ARS Administrator funded post-doc position to examine the use of plant viral vectors to influence plant gene expression.

Visiting Scientists

Maria **Cantor**
Dr. Cantor, professor from the University of Agricultural Sciences and Veterinary Medicine, in Cluj-Napoca, Romania, was a visiting scientist [August, 2005] working on cryopreservation of gladiolus.

EunJu **Cheong**
Dr. Cheong supported the shrub breeding unit [March 2001 - May 2006] by establishing in vitro organogenesis, embryogenesis and transformation systems of target plants and performed conventional breeding to develop non-invasive nursery crops as part of an SCA. Coordinated transformation experiments of Prunus species and maintained the tissue culture facility at the Arboretum. Dr Cheong also worked on characterization of the origin of *Prunus yedoensis* using ISSR and single nucleotide polymorphisms, as a volunteer with the WLPGR project.

Avner **Cohen**
Dr. Cohen, research scientist at the Volcani Center in Israel, was a visiting scientist on his sabbatical [August, 2000-August, 2001] working on genetic engineering of gladiolus for virus resistance.

Abed **Gera**
Dr. Abed Gera, head of the Dept. of Virology at the Volcani Center in Israel, was a visiting scientist [June-Aug, 2004] on sabbatical working on the detection of viruses in petunia.

Bong Hee **Han**
Dr. Han, research scientist from the Korea Rural Development Administration in Korea, was a visiting scientist [Jan., 2002-Jan., 2003] working on transformation of lilies.

Hyang Young **Joung**
Dr. Joung, director of the Floriculture lab at the Rural Development Administration in Korea, is a visiting scientist [August, 2005-April, 2006] working on cryopreservation of gladiolus shoot tips.

Young Hee **Joung**
Dr. Joung, assistant professor of Chonnam University in Korea, was a visiting scientist with Dr. Kamo [July-August, 2001; August, 2002] who worked on isolating a ubiquitin promoter from gladiolus. Dr. Joung previously worked from 1998-2001 with Dr. Roh on tissue culture propagation and transformation study of Campanula and characterization of Pinus sylvestris var. sylvestriformis using molecular markers.

Nam Sook **Lee**
Dr. Lee was a visiting scientist from March 2003 to February 2003, involved in projects on characterization of the *Ilex x wandoensis* complex using RAPD and ISSR markers, and assisting with characterization of campanula based on the morphological characteristics and molecular markers. Dr. Lee is currently a cooperator assisting various projects that include collecting leaf samples of *Corylopsis* in Korea and Japan, and making them available for WLPGR projects.

Anna Maria **Vaira**
Dr. Vaira is on sabbatical [December 2005 – December 2006] from the CNR Istituto Virologia Vegetale, Torino, Italy. Working on development of an infectious clone of *Lolium latent virus*, and investigating an ophiovirus infecting *Lachenalia*.

Adri **Veale**
Ms. Veale, scientist at Rhoodeplot in S. Africa, was a visiting scientist [June-July, 2001] who worked on transformation techniques.

COMMONLY USED ACRONYMS
OF
USDA, REE, AND ARS

AA	Associate Administrator
AAD	Associate Area Director
AAO	Area Administrative Officer
ABFO	Area Budget and Fiscal Officer
AC	Administrator's Council
AC	Accounting Code
ACS	Area Computer Specialist
AD	Area Director
ADA	Associate Deputy Administrator
ADAAM	Associate Deputy Administrator, Administrative Management
ADO	Authorized Departmental Officer
ADP	Automated Data Processing
ADODR	Authorized Departmental Officer's Designated Representative
A-E	Architect - Engineer
AES	Agricultural Experiment Station
AFM	Administrative and Financial Management
AGPMR	Agriculture Property Management Regulation
AHERA	Asbestos Hazard Emergency Response Act
AL	Annual Leave
ALOC	Acceptable Level of Competence
AM	Administrative Management
AO	Administrative Officer
AOD	Administrative Operations Division
APHIS	Animal and Plant Health Inspection Service
APMO	Area Property Management Officer
APO	Accountable Property Officer
ARD	Automatic Release Date
ARMP	Annual Resource Management Plan
ARMPS	Annual Resource Management Planning System
ARMS	ARS Resource Management System
ARS	Agricultural Research Service
ARS-CMU	ARS Correspondence Management Unit
ARS-LS	ARS Legislative Staff
ARS-OA	ARS Office of Administrator
ARSITS	Agricultural Research Service Invention Tracking System
ASB	Accounting Services Branch
ASHM	Area Safety and Health Manager
ATR	Agriculture Travel Regulations

AUO	Area Utilization Officer
AWOL	Absent Without Leave
BA	Beltsville Area
BARC	Beltsville Agricultural Research Center
BCA	Board of Contract Appeals
B&F	Budget and Fiscal
BFSB	Budget and Fiscal Services Branch, FMD
BLM	Bureau of Land Management
BOC	Budget Object Class
BPMS	Budget & Program Management Staff
BRM	Business Reply Mail
BSO	Biological Safety Officer
CAA	Clean Air Act
CAD	Contracting and Assistance Division
CD	Center Director
CDL	Commercial Drivers License
CDSD	Communications and Data Services Division
CDSO	Collateral Duty Safety Officer
CEP	Career Enhancement Program
CEPS	Cluster Environmental Protection Specialist
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Combined Federal Campaign
CFPDC	Consolidated Forms and Publications Distribution Center
CFR	Code of Federal Regulations
CG	Comptroller General
CMCO	Classified Material Control Officer
COLA	Cost of Living Allowance
CONUS	Continental United States
COP	Continuation of Pay
COR	Contracting Officer's Representative
CR	Civil Rights
CRAS	CRIS Resource Allocation Schedule
CRIS	Current Research Information System
CS	Contract Specialist
CSRA	Civil Service Reform Act
CSREES	Cooperative State Research, Education and Extension Service
CSRS	Civil Service Retirement System
CWA	Clean Water Act
DA	Deputy Administrator
DAAM	Deputy Administrator, Administrative Management
DAEA	Designated Area Ethics Advisor
DDES	Demonstration and Delegated Examining Section, NSB, PD
DEMO	USDA Demonstration Project
DEPPC	Departmental Excess Personal Property Coordinator
DEU	Delegated Examining Unit

DLA	Defense Logistics Agency, Department of Defense
DM	Department Manual
DMM	Domestic Mail Manual
DOD	Department of Defense
DOJ	Department of Justice
DPM	Department Personnel Manual
DR	Department Regulation
EAD	Extramural Agreements Division
EAP	Employee Assistance Program
EAS	Employee Appeals Staff
EC&R	Executive Correspondence and Records Unit, Office of Operations
EEO	Equal Employment Opportunity
EEOC	Equal Employment Opportunity Counselor
EEOO	Equal Employment Opportunity Officer
EO	Executive Order
EOD	Enter on Duty
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERC	Equipment Review Committee
ERRC	Eastern Regional Research Center
ERS	Economic Research Service
ESB	Extramural Services Branch, Contracting and Assistance Division
FAA	Foreign Agricultural Affairs, FAS
FAO	Food and Agricultural Organization
FARC	Federal Archives and Records Center
FAS	Foreign Agricultural Service
FBI	Federal Bureau of Investigation
FCMD	Facilities Construction Management Division
FD	Facilities Division
FDC	Financial Data Code
FECA	Federal Employees Compensation Act
FEHB	Federal Employees Health Benefits
FEORP	Federal Equal Opportunity Recruitment Program
FEPA	Federal Employee Pay Act
FEPCA	Federal Employees Pay Comparability Act of 1990
FERS	Federal Employees Retirement System
FES	Factor Evaluation System
FLSA	Fair Labor Standards Act
FMD	Financial Management Division
FOIA	Freedom of Information Act
FOMC	Facilities Operation Maintenance Contract
FPL	Full Performance Level
FPM	Federal Personnel Manual
FPMR	Federal Property Management Regulations
FPR	Federal Procurement Regulations

FPRS	Federal Property Resource Services, GSA
FR	Federal Register
FRC	Federal Records Center
FSC	Federal Supply Classification
FSS	Federal Supply Schedule
FT	Full Time Tour of Duty
FTCA	Federal Tort Claims Act
FTD	Federal Travel Directory
FTE	Full Time Equivalent
FTIS	Foreign Travel Information System
FTR	Federal Travel Regulations
FTS	Federal Telecommunications System
FTTA	Federal Technology Transfer Act
FTU	Foreign Travel Unit, FAS
FWS	Federal Wage System
FY	Fiscal Year
GAMS	Grants and Agreements Management Staff, CAD
GAO	General Accounting Office
GM	GS Employees in the Performance Management and Recognition System
GNA	Guide Not Applicable (decision)
GOV	Government Owned Vehicle
GPO	Government Printing Office
GTR	Government Transportation Request
GS	General Schedule
GSA	General Services Administration
GSD	General Services Division
HPRL	High Priority Requirement List
HQS	Headquarters
HRD	Human Resources Division, AFM
HWC	Hazardous Waste Cleanup
IDO	Informal Deciding Official
IDP	Individual Development Plan
IDR	Indepth Review or Reviewer
IFB	Insufficient Factual Basis (decision)
IH	Industrial Hygiene/Hygienist
IPSC	Indirect Program Support Cost
IR	Invention Report
IRS	Internal Revenue Service
IS	Information Staff
ISTD	Information Systems and Technology Division
ITP	Individual Training Plan
KSA	Knowledge, Skill and Ability
L/A	Letter of Authorization
LAO/LAT	Location Administrative Officer/Technician
LASER	Lincoln Advanced Science Engineering Reinforcement Program

LC	Location Coordinator
LD	Laboratory Director
LL	Location Leader
LERB	Labor Employee Relations Branch
LOC	Locations
LOTS	Location Obligation Tracking System
LS	Lead Scientist
LWOP	Leave Without Pay
M&IE	Meals and Incidental Expenses
MM	Mail Manager
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MRMD	Mail and Reproduction Management Division, Office of Operations
MSA	Mid South Area
MSPB	Merit Systems Protection Board
MU	Management Unit
MWA	Midwest Area
NAA	North Atlantic Area
NADC	National Animal Disease Center
NAL	National Agricultural Library
NARA	National Archives and Records Administration
NARS	National Archives and Records Service
NASS	National Agricultural Statistics Service
NCAUR	National Center for Agricultural Utilization Research
NEPA	National Environmental Policy Act
NFC	National Finance Center
NPA	Northern Plains Area
NPL	National Program Leader
NPS	National Program Staff
NRRC	Northern Regional Research Center
NSB	National Services Branch, PD
NTTC	National Technology Transfer Coordinator
NTE	Not to Exceed
NTIS	National Technology Information Service
OA	Office of the Administrator
OBPA	Office of Budget and Program Analysis, USDA
OCI	Office of Cooperative Interactions
ODS	Official Duty Station
O&F	Office of Operations and Finance
OGC	Office of General Counsel
OGE	Office of Government Ethics
OHMP	Occupational Health Maintenance Program
OICD	Office of International Cooperation and Development
OIG	Office of Inspector General
OMB	Office of Management and Budget

OO	Office of Operations
OP	Office of Personnel
OPF	Official Personnel Folder
OPM	U.S. Office of Personnel Management
OSEC	Office of Secretary
OSC	Office of Special Counsel
OSHA	Occupational Safety and Health Act/Administration
OSQR	Office of Scientific Quality Review
OTT	Office of Technology Transfer
OWCP	Office of Worker's Compensation
PA	Privacy Act
PA	Patent Advisor
PA	Program Analyst
PAA	Program Analyst Assistant
PAIS	Property Accounting Information System
PAO	Procurement Assistance Officer
PB	Publications Branch
PCB	Polychlorinated Biphenyls
PCMI	President's Council on Management Improvement
PCS	Permanent Change of Station
PC-TARE	Personnel Computer-Time and Attendance Remote Entry
PD	Personnel Division
pd	Position Description
PDS	Permanent Duty Station
PFT	Permanent Full Time
PIADC	Plum Island Animal Disease Center
PIP	Performance Improvement Plan
PL	Public Law
PM	Program Management
PMAR	Precious Metals Recovery Representative, Defense Logistics Agency, DOD
PMB	Property Management Branch
PMO	Property Management Officer
PMRS	Performance Management Recognition System
POB	Personnel Operations Branch, PD
POD	Post of Duty
POV	Privately Owned Vehicle
P&P	Policies and Procedures
PPPM	Payroll/Personnel Processing Manual
PPMS	Personal Property Management Section
PPSB	Personnel Policy and Systems Branch, PD
PRB	Performance Review Board
PRC	People's Republic of China
PSP	Position Staffing Plan
PT	Part Time Tour of Duty
PTO	Patent and Trademark Office

PVPA	Plant Variety Protection Act
PVPC	Plant Variety Protection Certificate
PWA	Pacific West Area
RA	Research Associate
RAP	Research Apprenticeship Program
RCRA	Resource Conservation and Recovery Act
REE	Research, Education and Economics
RG	Records Group
RGEG	Research Grade Evaluation Guide
RIF	Reduction in Force
RL	Research Leader
R&M	Repair & Maintenance
RMIS	Research Management Information System
RMO	Records Management Officer
RPEC	Research Personnel Evaluation Committee
RPES	Research Position Evaluation System
RSA	Research Support Agreement
RS#4	Reporting Section #4
RSS	Radiological Safety Staff
SAA	South Atlantic Area
SARA	Superfund Amendments and Reauthorization Act
SBG	Scored Below Grade
SES	Senior Executive Service
SEU	Special Examining Unit
SF	Standard Form
SGEG	Supervisory Grade-Evaluation Guide
SHEM	Safety, Health, and Environmental Management
SHEMB	Safety, Health, and Environmental Management Branch
SL	Senior Level
SL	Sick Leave
SOW	Statement of Work
SPA	Southern Plains Area
SPO	Servicing Personnel Office
SPS	Servicing Personnel Specialist
SR	Standard Regulations
SRRC	Southern Regional Research Center
ST	Scientific and Professional Pay Plan
SY	Scientist Year (Category 1 or 4 positions)
T&A	Time and Attendance
TAC	HQ and/or Area Time and Attendance Coordinator
TASSB	Technology Assessment and Support Services Branch
TC	Transaction Code (NFC T&A designation)
TCR	Tort Claims Representative
TDY	Temporary Duty
TEKTRAN	Technology Transfer Automated Retrieval System

TEP	Technical Evaluation Panel
TFT	Temporary Full Time
TMC	Travel Management Center
TPS	Target Percent in Salaries
TRAI	Training Information System
TSCA	Toxic Substance Control Act
TSP	Thrift Savings Plan
TT	Technology Transfer
TY	Travel Year
UPS	United Parcel Service
U.S.C.	United States Code
USDA	United States Department of Agriculture
USPS	United States Postal Service
USSR	Union of Soviet Socialist Republics
VRA	Veterans Readjustment Act
WG	Wage Grade
WGI	Within-Grade Increase
WNRC	Washington National Records Center
WOPFP	Without Postage and Fees Paid
WPFP	With Postage and Fees Paid
WRRC	Western Regional Research Center
YW	Pay Plan for Stay-in-School Students

ABBREVIATIONS OF USDA AGENCIES

Agency Abbreviation	Agency
ACS	Agricultural Cooperative Service
AMS	Agricultural Marketing Service
APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
ASCS	Agricultural Stabilization and Conservation Service
BA	Beltsville Area, Agricultural Research Service
BCA	Board of Contract Appeals
CCC	Commodity Credit Corporation
CSREES	Cooperative State Research, Education, and Extension Service
EAS	Economic Analysis Staff
EMS	Economics Management Staff
ERS	Economic Research Service
ES	Extension Service
FAO	Food and Agricultural Organization
FAS	Foreign Agricultural Service
FmHA	Farmers Home Administration
FCIC	Federal Crop Insurance Corporation
FGIS	Federal Grain Inspection Service
FNS	Food and Nutrition Service
FS	Forest Service
FSIS	Food Safety and Inspection Service
GAO	General Accounting Office
GIPSA	Grain Inspection and Packers and Stockyards Administration
GS	Graduate School (USDA)
HNIS	Human Nutrition Information Service
JO	Judicial Officer
NAL	National Agricultural Library
NARDAC	National Regional Data Automation Center
NASS	National Agricultural Statistics Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OAE	Office of Advocacy and Enterprise
OALJ	Office of Administrative Law Judges
OBPA	Office of Budget and Program Analysis
OCA	Office of the Consumer Advisor
OCE	Office of Chief Economist
OE	Office of Energy
OFM	Office of Finance and Management
OGC	Office of the General Counsel

OHR	Office of Human Resources
OICD	Office of International Cooperation and Development
OIG	Office of the Inspector General
OIRM	Office of Information Resources Management
OO	Office of Operations
OP	Office of Personnel
OPA	Office of Public Affairs
OT	Office of Transportation
PSA	Packers and Stockyards Administration
REA	Rural Electrification Administration
RTB	Rural Telephone Bank
SCS	Soil Conservation Service
SEC	Office of the Secretary
WAOB	World Agricultural Outlook Board

DEFINITION OF RPES

The Research Position Evaluation System (RPES) provides for review of ARS Category 1 positions on a cyclical basis to assure classification accuracy.

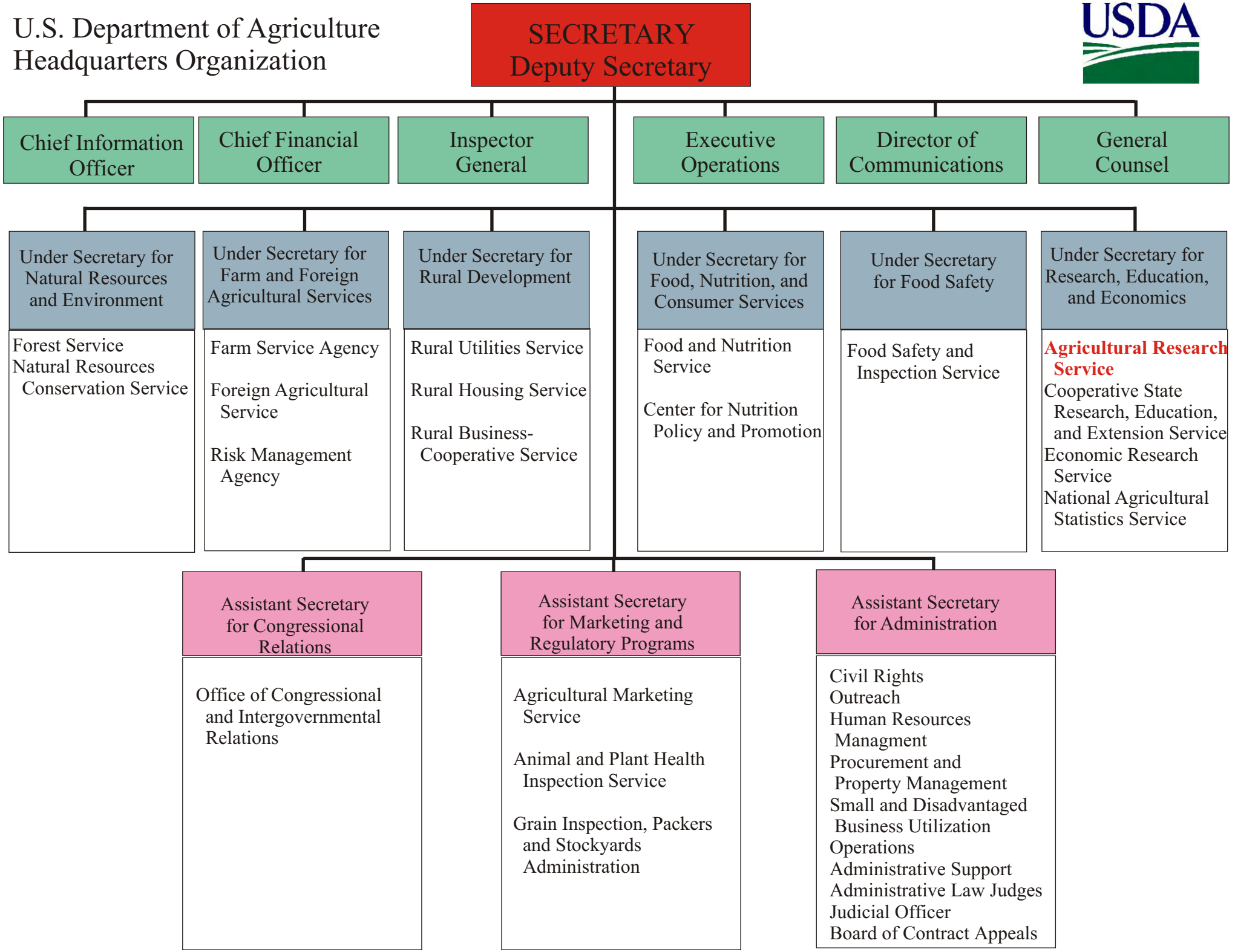
The RPES is based on the "person-in-the-job" concept. Under this concept, research scientists have open-ended promotion potential based on their personal research and leadership accomplishments, which can change the complexity and responsibility of their positions.

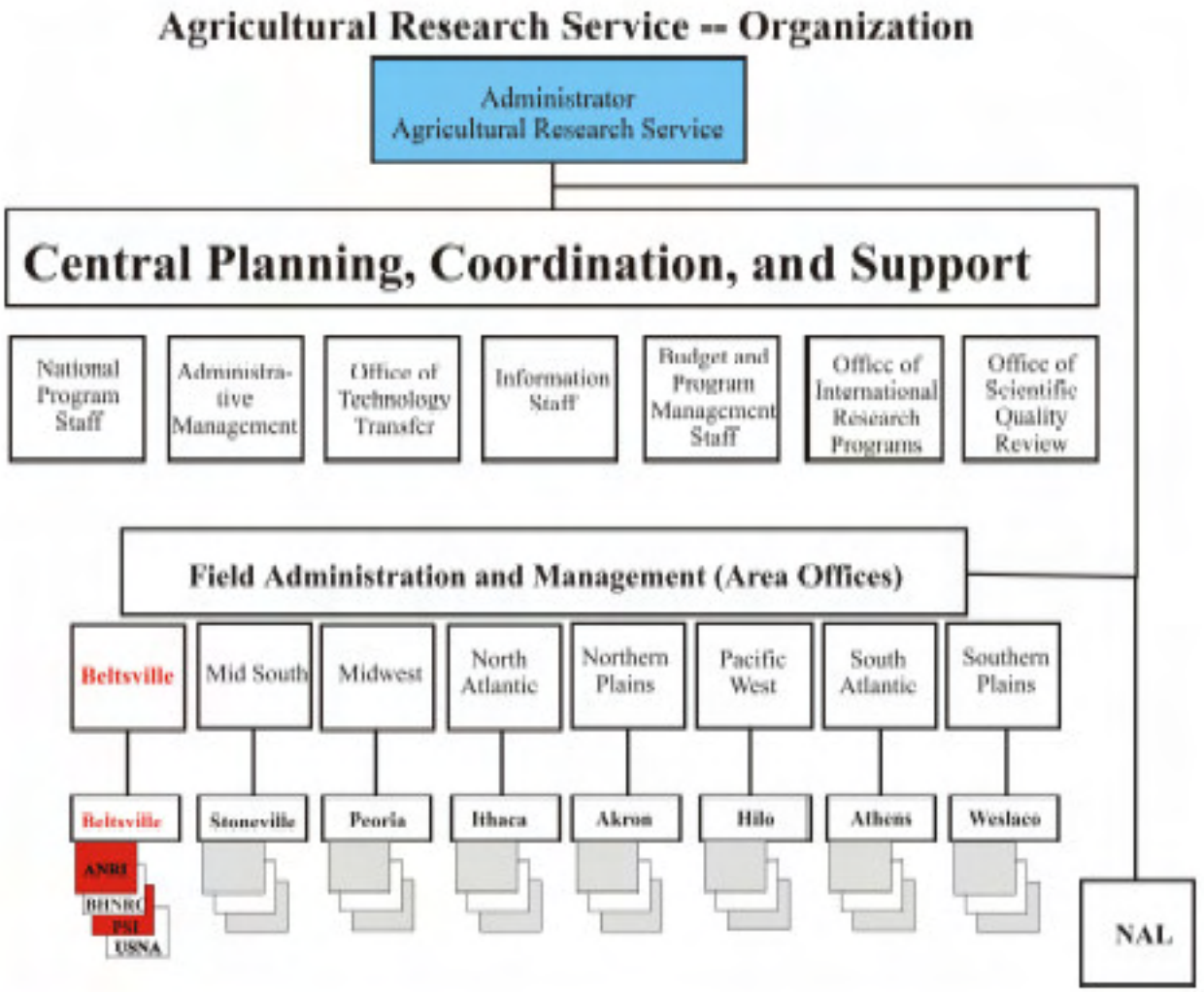
The RPES applies **only** to ARS Category 1 research positions. Other professional scientific positions are evaluated by application of appropriate U.S. Office of Personnel Management (OPM) classification standards.

DEFINITION OF OSQR

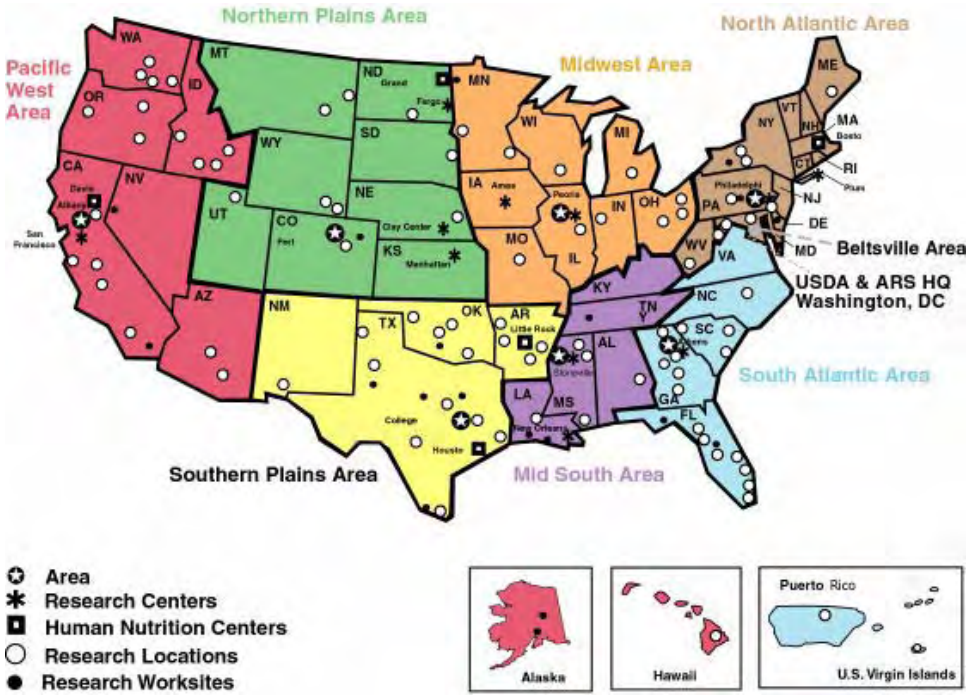
The Peer Review process conducted by the OSQR involves independent and expert scientific peer review of ARS project plans. This is a critical component of research planning. In this way, OSQR contributes to the National Programs focus on quality of ARS research.

U.S. Department of Agriculture
Headquarters Organization




Agricultural Research Service -- Organization
Administrator
Agricultural Research Service
Central Planning, Coordination, and Support
National Program Staff
Administrative Management
Office of Technology Transfer
Information Staff
Budget and Program Management Staff
Office of International Research Programs
Office of Scientific Quality Review
Field Administration and Management (Area Offices)
Beltsville
Mid South
Midwest
North Atlantic
Northern Plains
Pacific West
South Atlantic
Southern Plains
Beltsville
Stoneville
Peoria
Ithaca
Akron
Hilo
Athens
Weslaco
ANRI
BHNRC
PSI
USNA
NAL

ARS Research Locations



- **Beltsville Area**

  Beltsville, MD & Washington, DC
- **Mid South Area**

  Alabama, Kentucky, Mississippi, Louisiana, Tennessee
- **Midwest Area**

  Iowa, Illinois, Indiana, Michigan, Minnesota, Missouri, Ohio, Wisconsin
- **North Atlantic Area**

  Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia
- **Northern Plains Area**

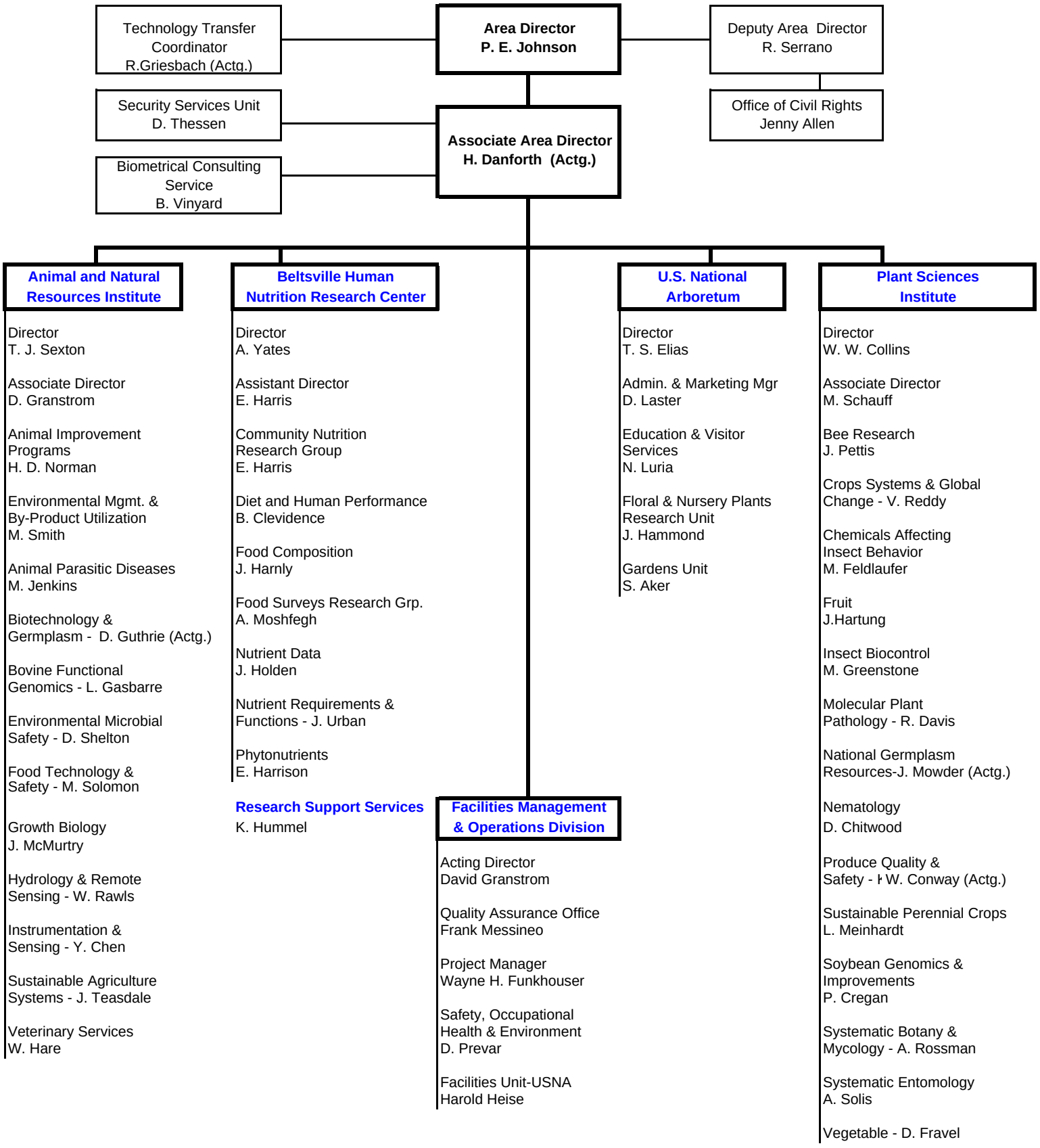
  Colorado, Kansas, Montana, North Dakota, Nebraska, South Dakota, Utah, Wyoming
- **Pacific West Area**

  Arizona, California, Hawaii, Idaho, Nevada, Oregon, Washington
- **South Atlantic Area**

  Florida, Georgia, North Carolina, Puerto Rico, South Carolina, Virginia, Virgin Islands
- **Southern Plains Area**

  Arkansas, New Mexico, Oklahoma, Texas, Panama
- **International Locations**

USDA, AGRICULTURAL RESEARCH SERVICE
BELTSVILLE AREA



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